Taft-Bell Sediment and Fishery Monitoring Project

BPA

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Bonneville Power Ac

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DEPARTMENT OF FISH AND GAME

Jerry M. Conley, Director

TAFT-BELL SEDIMENT AND FISHERY MONITORING PROJECT

Phase I Completion Report

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ABSTRACT

In May 1985, we initiated the first two years of a ten-year monitoring study designed to assess the potential effects on fishery resources in the Idaho Panhandle's Coeur d'Alene River and Hayden Creek watersheds from the construction of the BPA Taft-Bell 500 kV power line.

During 1985 and 1986, we surveyed a total of 21 streams in the Coeur d'Alene River and Hayden Creek drainages. In those streams, we estimated trout abundance in 52 snorkel and 16 electrofishing transects, collected sediment core samples from 66 transects and measured substrate embeddedness at 61 stream locations. We also conducted trout habitat inventories on all 21 study streams. The results from the first two years' work established a monitoring framework and provided baseline data to compare with the eight years of information following the completion of construction activities in 1986.

Coeur d'Alene River tributaries are generally supporting low densities of trout. Although our sediment analysis suggests that cutthroat trout spawning success in Coeur d'Alene River and Hayden Creek tributaries could be depressed, there is no significant relationship (pª0.05) between either percent embryo survival estimates or percent fine sediment measurements and overyearling trout densities. Analysis of the first two years of data and our field observations indicate that instream habitat conditions may be more limiting to cutthroat trout populations than the effect of fine sediments on embryo survival. These preliminary data do not allow an analysis of Taft-Bell construction effects on trout populations in the study streams. A comprehensive evaluation of Taft-Bell effects on trout populations in the Coeur d'Alene River and Hayden Creek drainages will be made at the end of the ten-year study.

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INTRODUCTION

Beginning in the spring of 1986 through the fall of 1987, the Bonneville Power Administration (BPA) will construct the final leg of the Garrison-Spokane 500 kV transmission line across northern Idaho. Extending from the Taft substation near Saltese, Montana, to the Bell substation near Spokane, Washington, the Taft-Bell transmission line will complete the final link between the Colstrip power generating facility located east of Hardin, Montana, and the BPA power grid at Spokane. As it crosses northern Idaho, the route of the Taft-Bell transmission line traverses a number of drainages important to the maintenance of valuable salmonid fisheries in the Coeur d'Alene River, Coeur d'Alene Lake and Hayden Lake (Figure 1).

Historically, the Coeur d'Alene River, Coeur d'Alene Lake and Hayden Lake supported exceptional westslope cutthroat trout *Salmo clarki lewisi* fisheries. Among other northern Idaho waters including the St. Joe and Moyie rivers, the Coeur d'Alene River was recognized in the early 1900s as one of the top trout fishing waters in the United States. However, by 1970, cutthroat trout numbers had declined dramatically due to angling overharvest and loss of habitat from mining, logging and road construction activities. A 1973 study characterized the Coeur d'Alene River trout fishery as marginal, being supported by low numbers of fish (Bowler 1974). In 1975, the Idaho Department of Fish and Game (IDFG) implemented restrictive angling regulations on the upper mainstem and North Fork of the Coeur d'Alene River. Those regulations (13 in. minimum size; 3 fish daily limit; artificial lures only) were patterned after similar regulations on two neighboring drainages (St. Joe River and Kelly Creek) which successfully reduced overexploitation and increased cutthroat trout numbers (Johnson and Bjornn 1978). However, trout populations in the Coeur d'Alene River did not respond to the regulation changes as hoped. Lewynsky and Bjornn (1983) reported that although cutthroat trout numbers had stabilized in the upper Coeur d'Alene River, overall size and numbers of fish had not increased. By 1985, IDFG closed the upper Coeur d'Alene River to the harvest of trout in order to protect those populations. As the agency responsible for managing fish and wildlife habitat in the Coeur d'Alene drainage, the U.S. Forest Service (USFS) has implemented land management regulations for the protection of cutthroat trout populations. Responding to public concerns about declines in fish habitat quality, the USFS in its draft 10-Year Forest Plan (April 1985) withheld 49 stream drainages on the Idaho Panhandle National Forest (IPNF) from scheduled timber harvest and road construction activities.

Environmental criteria by which the Forest Service designates drainages for nonscheduled status includes density of roads in the drainage, percentage of the drainage with timber harvest and measured levels of instream fine sediments. Designated nonscheduled drainages are withdrawn from major timber harvest and road development activities for at least a ten-year period to allow watershed recovery.

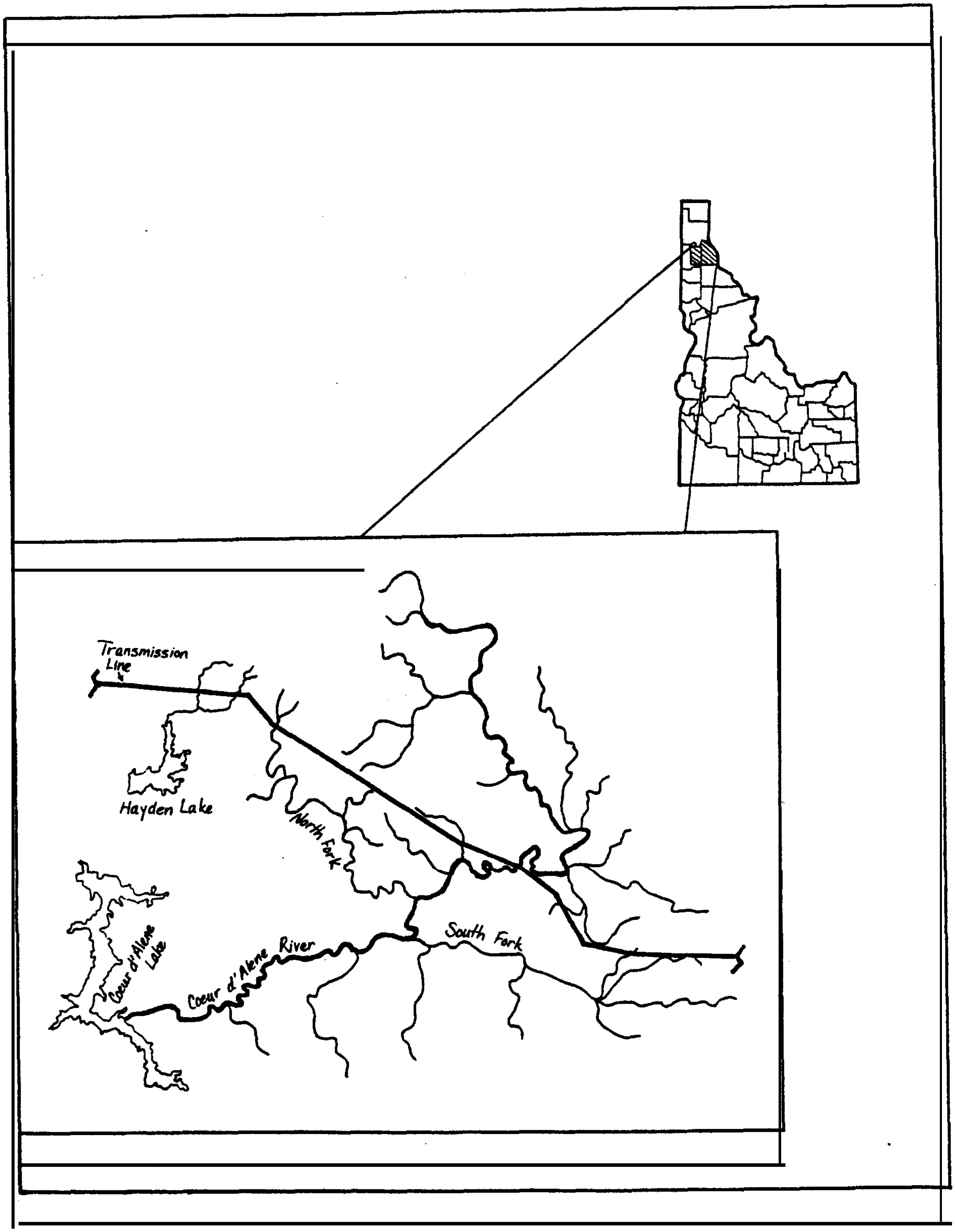


Figure 1. Coeur d'Alene River basin, Coeur d'Alene Lake, Hayden Lake and Taft-Bell transmission line route, northern Idaho.

The USFS and the IDFG are concerned about the potential for additional loss of fish production and habitat because the Taft-Bell transmission line will bisect the heart of the Coeur d'Alene River system, including 11 nonscheduled drainages (Figure 2) at a time when cutthroat trout populations are depressed. In response to those concerns, the BPA, as part of its Mitigation and Monitoring Plan, is funding a ten-year joint USFS/IDFG fish habitat and population monitoring study. Project participants agreed on ten years as the project duration in order to ensure an adequate amount of time to evaluate potential effects on fish populations by the Taft-Bell project. During the first two years of this project, the IDFG is responsible for the design and implementation of the ten-year study. USFS biologists will carry out the subsequent eight years of stream monitoring.

OBJECTIVES

The major objectives for the entire ten-year monitoring study are twofold:

1. To assess the effects of the Taft-Bell transmission project on trout habitat and populations in selected Coeur d'Alene River and Hayden Lake tributaries; and

2. To evaluate the effectiveness of BPA mitigation measures designed to reduce impacts to trout habitat and populations in Coeur d'Alene River and Hayden Creek tributaries effected by the Taft-Bell transmission line project.

The objectives of this phase of the ten-year monitoring study were to:

A. Design a study to meet the two overall project objectives.

B. Collect the first two years of baseline trout density and stream sediment data to compare with postconstruction data.

C. Document any point-source sediment contributions caused by the Taft-Bell project.

D. Identify those study streams most important for the production of westslope cutthroat trout.

E. Identify factors, other than fine sediment, which may be limiting westslope cutthroat trout production in the study area.

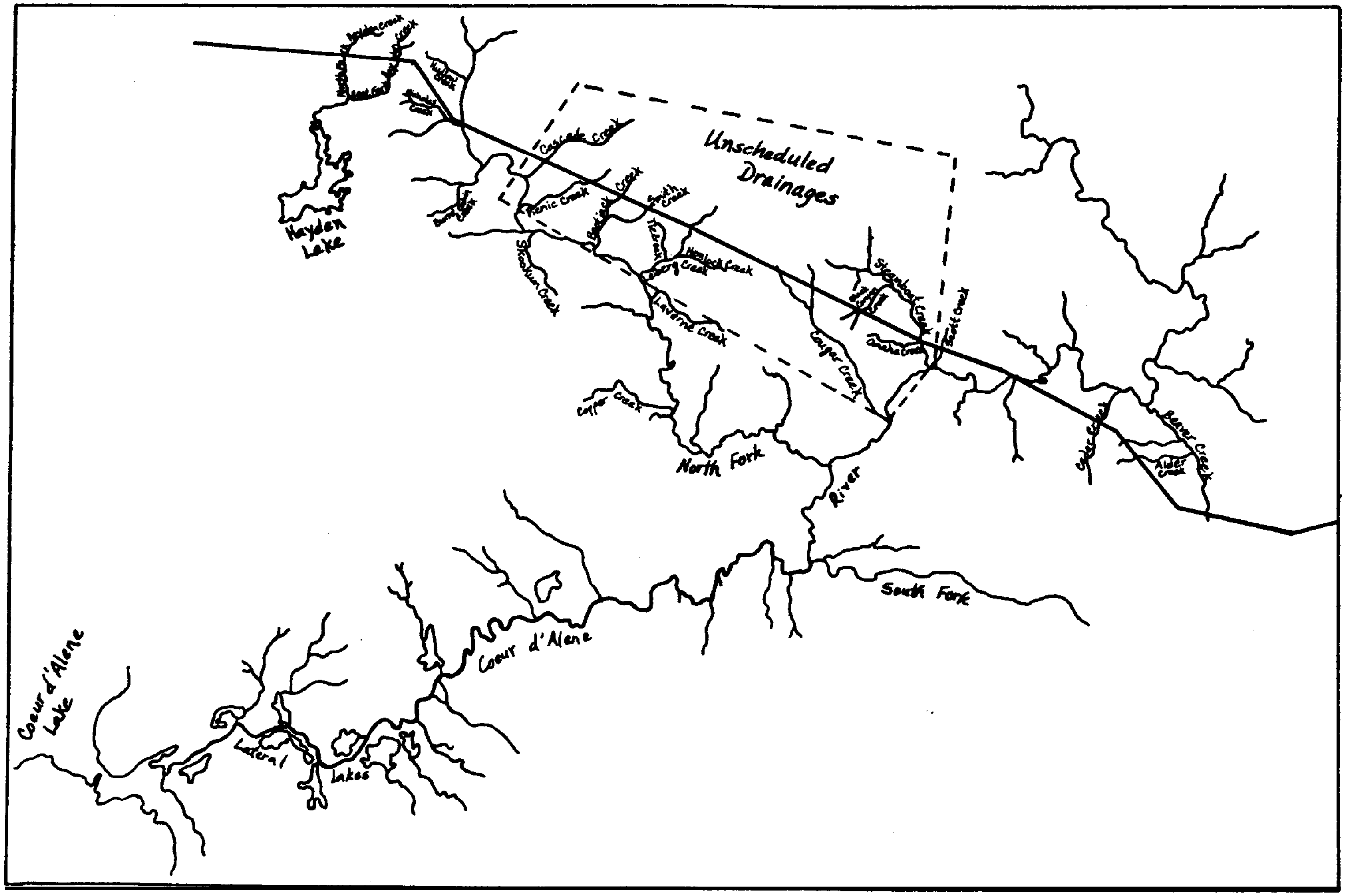


Figure 2. Taft-Bell transmission line route and IPNF unscheduled stream drainages, northern Idaho.

DESCRIPTION OF THE STUDY AREA

The Coeur d'Alene River drains a watershed roughly 2,320 km^2 (895 square miles) in an **area** bounded to the east by the Bitterroot Mountain Range, to the south by the St. Joe Mountain Range and to the west by the eastern portion of the Columbia Plateau. The terrain within the drainage is steep, with sidehill gradients typically ranging from 50 to 70X. Elevations range from 640 m (2,100 ft.) to 2,080 m (6,826 ft.).

The Coeur d'Alene River drainage is entirely underlaid by metamorphic sediment material (argillites and quartzites) of the Belt supergroup. Soil formations are generally a moderately deep (51-102 cm; 20-40 in.) loam complex with a comparatively low potential for surface erosion and mass failure. Soil mapping has distinguished five major soil units within the drainage, two of which are prominent in the study area and are developed on hard bedrock (hard quartzite, argillite and sandstone). These soils vary in depth from 51-102 cm (20-40 in.) and contain a large amount of coarse fragments which increase with depth. Group IV soils are found at higher elevations (1,372 m; 4,500 ft.) on forest mountain and ridge tops and are developed over both hard and soft argillite bedrock. Road building and other forest management problems are expected on these soils because of shallow depths, dip in bedrock and large amounts of coarse fragments. Overall, the soils in the Coeur d'Alene drainage are highly stable.

Annual precipitation in the drainage averages 111 cm (44 in.) and has ranged over the past ten years from 69 cm (27 in.) to 160 cm (63 in.). Peak winter snowpack runoff occurs in March and April, although rain-on-snow events are common in winter months and frequently result in midwinter floods. Peak flows during rain-on-snow events are often twice the average spring runoff peak.

The Coeur d'Alene River drainage is intensely managed for timber production and harvest and, consequently, is heavily roaded. The Fernan Ranger District which encompasses the majority of study streams has roughly 2,500 miles of road, with a mean road density of 4.5 miles of road per square mile area.

The combination of steep terrain, highly fractured bedrock parent material, high precipitation punctuated by wintertime rain-on-snow events and high density of roads are important factors influencing the channel morphology and stability of Coeur d'Alene River tributaries and trout populations.

RECOMMENDATIONS

1. Continue to use cobble embeddedness as a measure of sediment recruitment.

2. Use the Tappel technique as the primary method of estimating embryo survival.

3. Continue to use percent sediment less than 6.4 mm diameter and the Fredle index as measures of sediment composition, but do not use them as estimators of embryo survival.

4. Monitor Scott, Tie, Leiberg and Line creeks on a yearly basis and the remainder of the study streams on an alternate year basis.

METHODS

Four categories of observations were gathered during this project. In 1985, we assessed trout abundance, trout habitat and sediment levels in stream substrate to provide baseline observations against which to measure potential effects of the Taft-Bell power line on trout populations. We also monitored specific construction activities such as culvert placement and stream crossing work to document point-source sediment recruitment in selected streams. In 1986, we estimated trout abundance, collected substrate sediment data and again monitored construction activities. During the spring of 1986, we also trapped outmigrating trout in selected streams to identify important streams for adfluvial cutthroat trout production.

Trout Abundance

Trout abundance transects were selected downstream from construction activities for observations of power line project effects. We also established trout abundance transects above construction work in two study streams to provide control observations. These transects were selected from stream sections representative of good trout habitat and were documented with written descriptions and photographs to facilitate identification in the future. I considered pools and runs with overhead cover and water depths greater than one foot to be preferred trout habitat. When possible, we estimated trout densities using conventional underwater snorkeling techniques described by Lewynski (1983) and Thurow (1976). When low water or poor visibility made snorkeling impractical, trout densities were estimated using electrofishing equipment and a two-pass depletion method (Seber and LeCren 1967). Fish enumerated by snorkeling observations were recorded by species and age group. I estimated the age of observed fish (designating them as fry, age 1+, age 2+, etc.) based on known length at age data collected from study streams during the project (Table 1) and their apparent length frequencies while snorkeling. Fish collected with electrofishing equipment were measured to the nearest millimeter and were recorded by species.

The total length and mean width (from a minimum of ten equally spaced measurements) of each snorkel and electrofishing transect were measured as soon as possible following each abundance estimate to derive fish densities (per 100 m^2) for each study stream transect. Electrofishing transects were generally 100 m or more in length. Snorkel transect lengths varied, depending on the size of each stream and its morphological characteristics. Most snorkel transects were 20-40 m in length.

Table 1. Length at age data for cutthroat trout from Coeur d'Alene River tributaries, northern Idaho, 1985 and 1986.

Age	N	Median length (mm)	Mean length (mm)	Length range (mm)	S.E.
1+	29	93	99	71 - 158	4.1
2+	33	125	129	82 - 175	4.3
3+	15	160	167	138 - 220	7.0
4+	4	173	180	163 - 199	7.8

Spring Migrant Cutthroat Movement

During the spring of 1986, we monitored downstream movement of juvenile cutthroat trout in selected streams to identify tributaries important for the production of fluvial or adfluvial stocks. Previous investigators have documented a springtime downstream migration of juvenile cutthroat trout presumed to be destined to rear in the lower river or lake (Averett 1963; Rankel 1971; Lukens 1978). A portable fyke net trap was used to monitor each selected stream for at least one 12-hour night period. Most streams were monitored on two or more nights. Specific sites were selected for trap placement to ensure optimal trapping efficiency. Channel constrictions near the channel mouths offered the best opportunity to intercept the majority of downstream trout movement. Because we did not completely weir the channels, we could not be certain of 1002 trapping efficiency; however, in most cases we were able to intercept nearly all of the stream channel. I estimated that trapping efficiency was 752 or better at each trapping site. Our objective was not to generate accurate estimates of downstream movement, but rather to understand the relative contribution of each stream to a migratory cutthroat stock in the Coeur d'Alene River drainage.

Trout Habitat

We used a stream habitat evaluation method (Appendix A) developed by IPNF biologists to inventory trout habitat in each stream study reach. Study reaches of stream being monitored for construction effects include control and impacted sections. Beginning at the lower end of each stream study reach, habitat types were selected for measurement by pacing a previously determined random number of steps upstream. When the surveyor stopped, he classified the stream habitat type at his position and measured its total length and average width (from equally spaced intervals). Habitat types classified by this method include four pool classes (1-4), runs, glides, pocketwater and riffles. Suitable spawning sites at least two square meters in area were counted in each survey section: and roughness elements, such as logs, root wads or boulders, creating instream cover and spawning sites were recorded. The gradient of each survey section was measured using a pocket clinometer. Structural features such as undercut banks and overhanging vegetation which provide overhead cover were also recorded. After completing these measurements and recording his observations from the selected stream habitat section, the surveyor again paced a random number of steps and repeated the procedure to the end of the stream study reach.

Substrate Sediment Composition

We assessed the suitability of stream substrates for cutthroat trout spawning by analyzing core samples collected with a 15 cm diameter McNeil substrate sampler and a 15 cm diameter sampling tube patterned after the McNeil sampler (Figure 3). Coring transects (three per treatment or control study reach) were located in potential spawning areas located at a.

b.

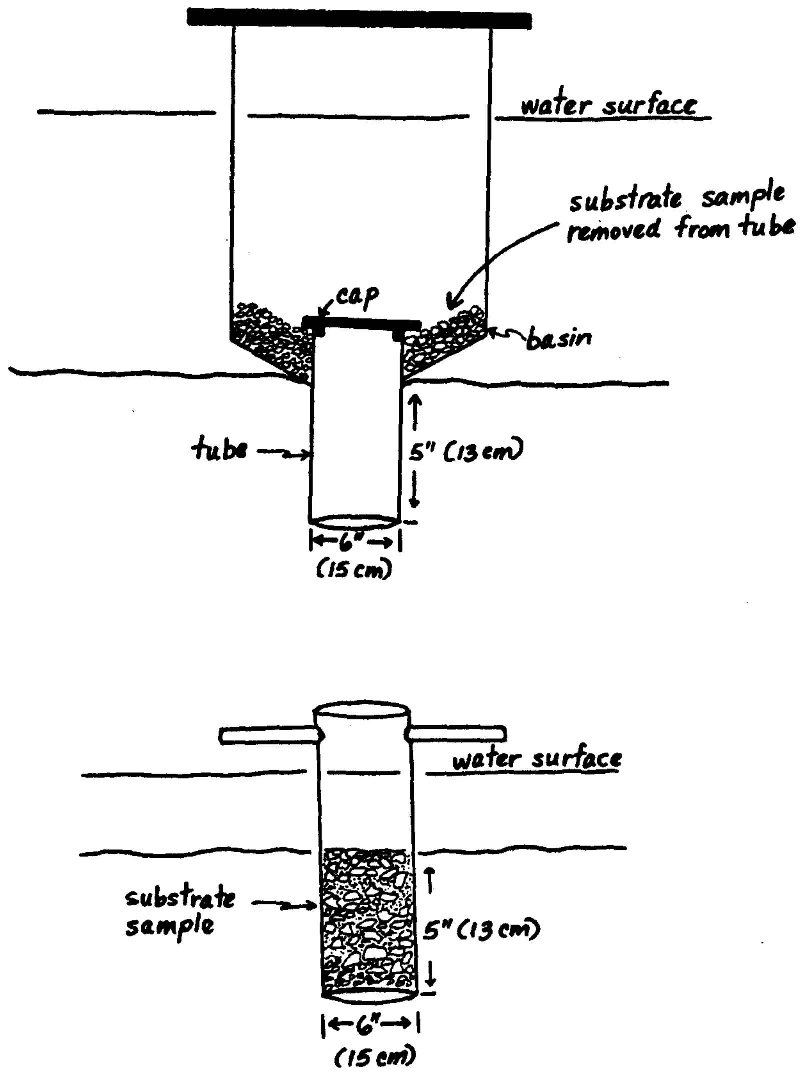


Figure 3. a. Standard McNeil hollow core substrate sampler.

b. Modified hollow core substrate sampler.

"tail-outs" (downstream depositional areas) of pools. The core samples were collected by pushing the sample tube into the substrate to a depth of 13 cm (5 in.) to approximate the depth of cutthroat trout redds (Smith 1945) and removing the core samples (3 to 7 at each transect) by hand from the tube. Each sample was individually sacked, labeled and later analyzed at the IPNF soils analysis laboratory at Sandpoint, Idaho. The core samples were oven-dried for three hours at 82°C, then sorted through a geometric sieve series (64 mm, 32 mm, 16 mm, 9.5 mm, 8 mm, 6.4 mm, 4 mm, 2 mm, 1 mm, 0.85 mm, 0.5 mm, 0.25 mm, 0.125 mm, 0.0625 mm) for four minutes on a Ro-Tap mechanical shaker. The percent particle size distribution of substrate sampled at each transect was calculated from the weights of the individual sieved fractions of the core samples taken from the respective transect. The overall suitability of the stream substrate at each transect for cutthroat trout spawning was estimated from the percent particle size distributions using methods developed by McCuddin (1977), Tappel and Bjornn (1981) and Lotspeich and Everest (1981) (Appendix B).

The percent embeddedness of large substrate matrix particles in fine particles (less than 6.4 mm diameter) was also measured using the method described by Burns (1983). With this technique, particle embeddedness is measured for a minimum of 100 randomly selected particles (Figure 4). The degree of substrate embeddedness is described by two statistics: percent particle embeddedness and the percent of measured particles free of embeddedness.

On-Site Monitoring

Monitoring of site-specific point-source sediment recruitment was conducted on a regular basis and consisted of written descriptions of observations, in addition to photographs taken at permanent locations (photo points), to document slumping of road-fill material, surface erosion, culvert failures or other significant point-source sediment contributions to the stream.

RESULTS

Trout Abundance

Species Composition

Cutthroat trout were the predominant trout species in the study streams. I also observed small numbers of brook trout *Salvelinus fontinalis* in eight streams and found rainbow trout *Salmo gairdneri* in five study streams (Table 2).

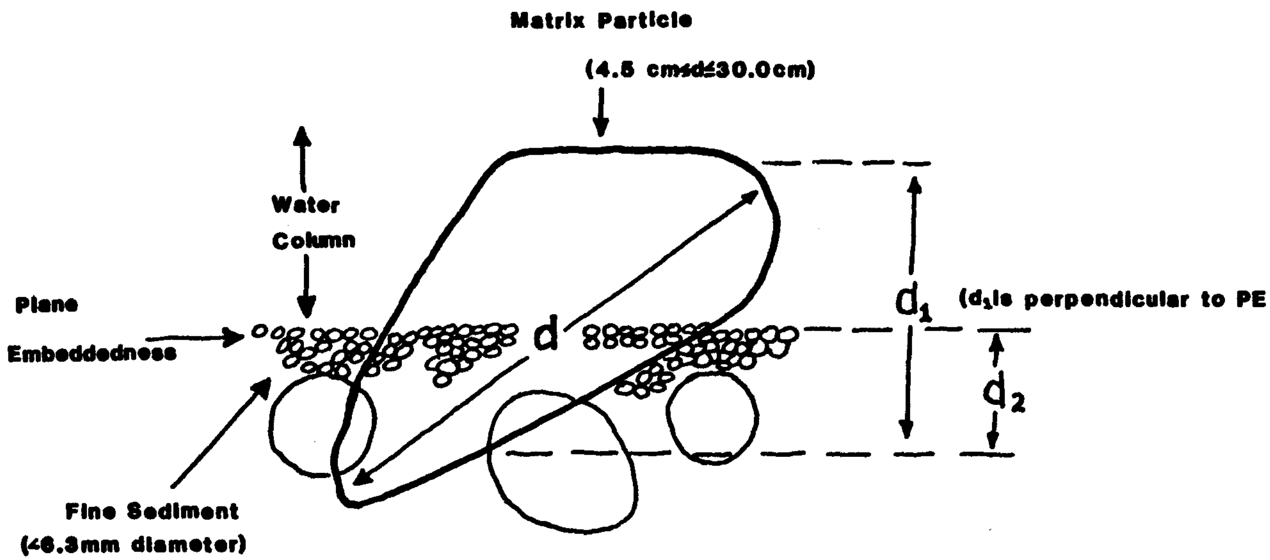


Figure 4. Embeddedness [$E=d_2/d_1(100)$] is defined as the percentage of the longest diameter of a matrix particle which is perpendicular to the plane of embeddedness (P_E) divided into the portion (D_2) of the length which is below the plane of embeddedness (Burns 1984).

Table 2-a. Trout overyearling (age 1+) and fry densities in Coeur d'Alene River and Hayden Creek tributaries, northern Idaho, 1985.

	Trout densities (fish/100 m^2)[a]			
	Age 1+			
Stream	CTT	BKT	RBT	Fry
N. Fk. Hayden	46.7			
E. Fk. Hayden	24.5	2.1		[b]
Black Canyon	10.3			[b]
Scott	10.2			
Copper	8.9	3.6		5.7
Omaha	7.9			
Hudlow	8.1			0.3
Leiberg	8.0	0.1		5.1
Tie	5.8	0.4		0.4
Nicholas	5.1			
Line	4.9			14.5
Laverne	3.4			
Cascade	2.6		2.6	2.2
Hemlock	2.5			
Alder	2.3	0.6		
Bootjack	2.1			2.1
Picnic	7.5			
Cedar	0.5		0.7	0.2
Skookum	0.4	0.5		
Burnt Cabin				0.4
Smith				

[a]CTT - cutthroat trout
BKT - brook trout
RBT - rainbow trout
[b]Fry densities were too great to count accurately.

Table 2-b. Trout overyearling (age 1+) and *fry* densities in Coeur d'Alene River and Hayden Creek tributaries, northern Idaho, 1986.

	Trout densities (fish/100 m^2)[a]				
	Age 1+				
Stream	CTT	BKT	RBT	Total	Fry
N. Fk. Hayden	56.6	2.8	1.4	60.8	105.8
E. Fk. Hayden	35.2	4.0	0.2	39.4	68.7
Black Canyon	12.4			12.4	8.8
Scott	7.9			7.9	1.3
Copper	8.0	6.0		14.0	
Omaha	18.3	present	present	18.3	29.4
Hudlow[b]					
Leiberg	6.8			6.8	
Tie	13.1			13.1	0.6
Nicholas	5.2			5.2	
Line	29.9			29.9	11.9
Laverne	4.4			4.4	
Cascade	3.8			3.8	0.9
Hemlock	3.1	3.0		6.1	
Alder	1.7	3.3		5.0	
Bootjack	1.3			1.3	
Picnic	9.4			9.4	1.6
Cedar			0.7	0.7	1.5
Skookum[b]					
Burnt Cabin[b]					
Smith[b]					

[a]CTT = cutthroat trout
BKT = brook trout
RBT = rainbow trout
[b]Not sampled.

Trout Densities

Trout densities were low in the majority of streams, especially in tributaries to the North Fork Coeur d'Alene River. Densities in the 21 streams surveyed during 1985 varied considerably, ranging from 40.7 age 1 and older trout per 100 m^2 in the North Fork of Hayden Creek to no fish observed in both Smith and Burnt Cabin creeks, tributaries of the North Fork Coeur d'Alene River. Densities during 1986 ranged from a high of 64.1/100 m^2 in the North Fork of Hayden Creek to no fish again in Smith Creek (Figure 5). Previous investigators have reported cutthroat trout densities in tributaries of the neighboring St. Joe River, streams sharing similar environmental factors (climate, land type and topography) which are generally higher than those I observed in Coeur d'Alene River tributaries (Tables 3-5). The Hayden Creek drainage was a notable exception, with 1985 densities of 40.7 and 26.6 and 1986 densities of 68.5 and 39.4 age 1 and older trout per 100 m^2 in the North Fork and East Fork, respectively. Fry densities in both streams were too high to accurately count in 1985. I estimated fry densities in both the North and East forks of Hayden Creek to be greater than 150 per 100 m^2 in my snorkel transects that year. In 1986, I observed fry densities of 98.5 and 68.7/100 m^2 in each stream.

Age Structure

Age structures of the fish populations varied slightly among Coeur d'Alene River tributaries, but markedly between populations in Hayden Creek and the remainder of the study streams. Hayden Creek cutthroat trout populations were predominantly represented by age groups 1+ and 2+, while populations in the remainder of study streams generally included more age 3+ and age 4+ trout (Figure 6).

Habitat Conditions

Instream trout habitat is suboptimal in the majority of stream study reaches. Most streams are dominated by shallow riffle and pocket water habitat types, while relatively small areas of the stream study reaches were classified as pool or run habitat types preferred by cutthroat trout (Figure 7). Stream flows in several sections of study streams were too low to support fish populations by midsummer. Nicholas, Line, Smith, Hemlock, Tie, Black Canyon, Scott, Omaha and Alder creeks were too low to snorkel by mid-July. Substantial sections of Picnic, Bootjack and Smith creeks were dewatered during the same period. Excessive bedload sediment deposits, comprised of gravel to small cobble-sized particles, in many cases filled stream channels, creating a porous "pad" of substrate material through which the stream flowed subsurface. Streams that were characterized by excessive bedload sediment deposits and retained surface flows through the summer were generally poor in fish holding or rearing habitat and supported lower densities of fish than did streams with lower bedload sediment levels. Large organic debris (primarily fallen trees), boulders and other roughness elements are conspicuously absent or infrequent in the "habitat poor" stream sections.

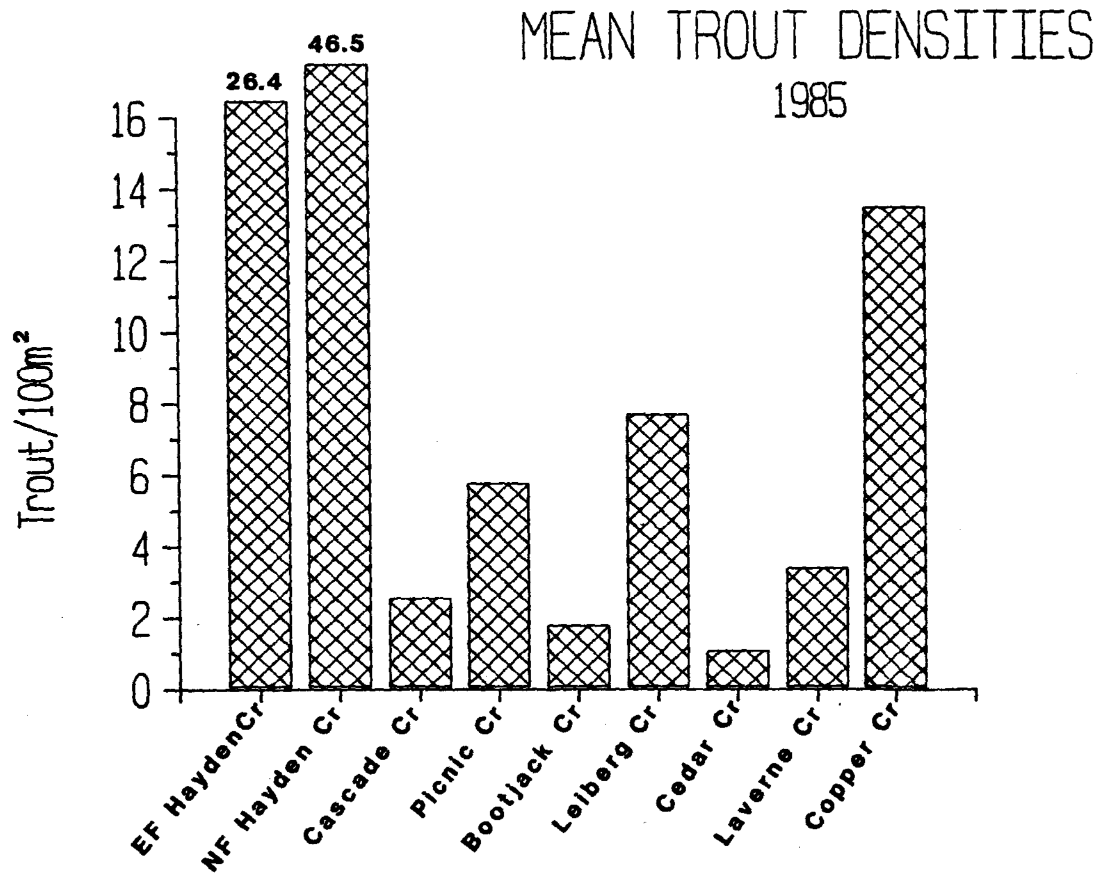


Figure 5-a. Mean densities (per 100 m^2) of age 1 and older trout from snorkel observations in Taft-Bell study streams, northern Idaho, 1985.

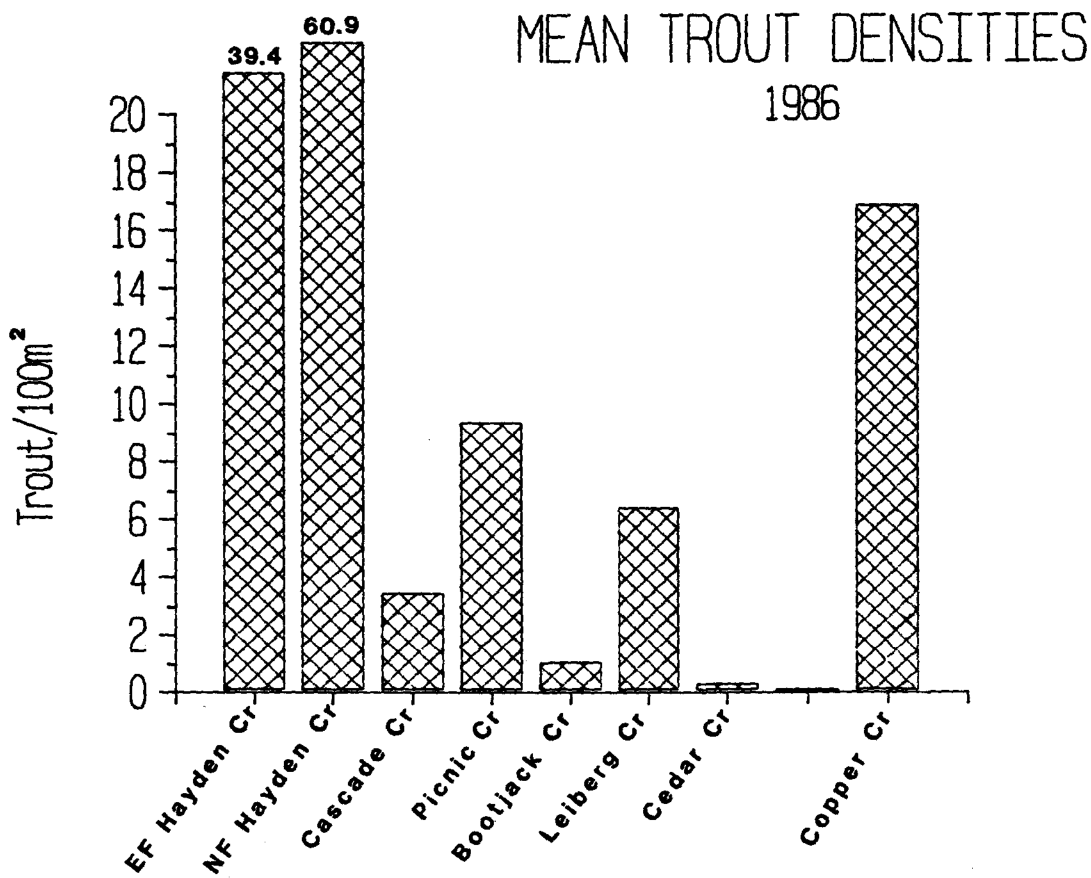


Figure 5-b. Mean densities (per 100 m^2) of age 1 and older trout from snorkel observations in Taft-Bell study streams, northern Idaho, 1986.

Table 3. Densities of age 1 and older trout (per 100 m^2) in selected St. Joe River tributaries, northern Idaho.

Stream	1973[a]	1974[a]	1975[a]	1981[b]	1982[b]
Big Creek	21.0	16.7	14.3	6.7	22.9
Marble Creek	2.9	4.4	2.8	1.3	10.0
Mica Creek	8.3	5.3	8. 8		6.7

[a]Thurow 1976.
[b]Gamblin 1984.

Table 4. Summary of fish densities (trout/100 m^2) in snorkeling transects of the Coeur d'Alene River, Idaho, 1984 (Horton 1985).

Stream	Cutthroat trout	Rainbow trout	Unidentified trout	Brook trout	Total
Willow	43.7				43.7
Evans	24.8				24.8
Fortier	42.9			4.3	47.2
Latour	6.6				6.6
Cougar Gulch	18.3	17.5			35.8
W. Fk. Steamboat	4.2				4.2
E. Fk. Steamboat	9.8				9.8
Steamboat	0.3	0.5	0.2	0.1	1.1
Coal	9.6				9.6
Graham	0.8			3.2	4.0
Brown	9.2	42.9			52.1

Table 5. Summary of fish densities (trout/100 m^2) in snorkeling transects in Wolf Lodge Creek and tributaries, Idaho, 1975 and 1976 (Lukens 1978).

	Cutthroat trout		Brook trout	
Stream	1975	1976	1975	1976
Wolf Lodge Creek	60	32	2	5
Searchlight Creek		287		
Stella Creek	83	162	1	14
Marie Creek	60	93	22	14
Clear Cut Creek	500	227		
Lonesome Creek	152	204		15
Cedar Creek	97		6	

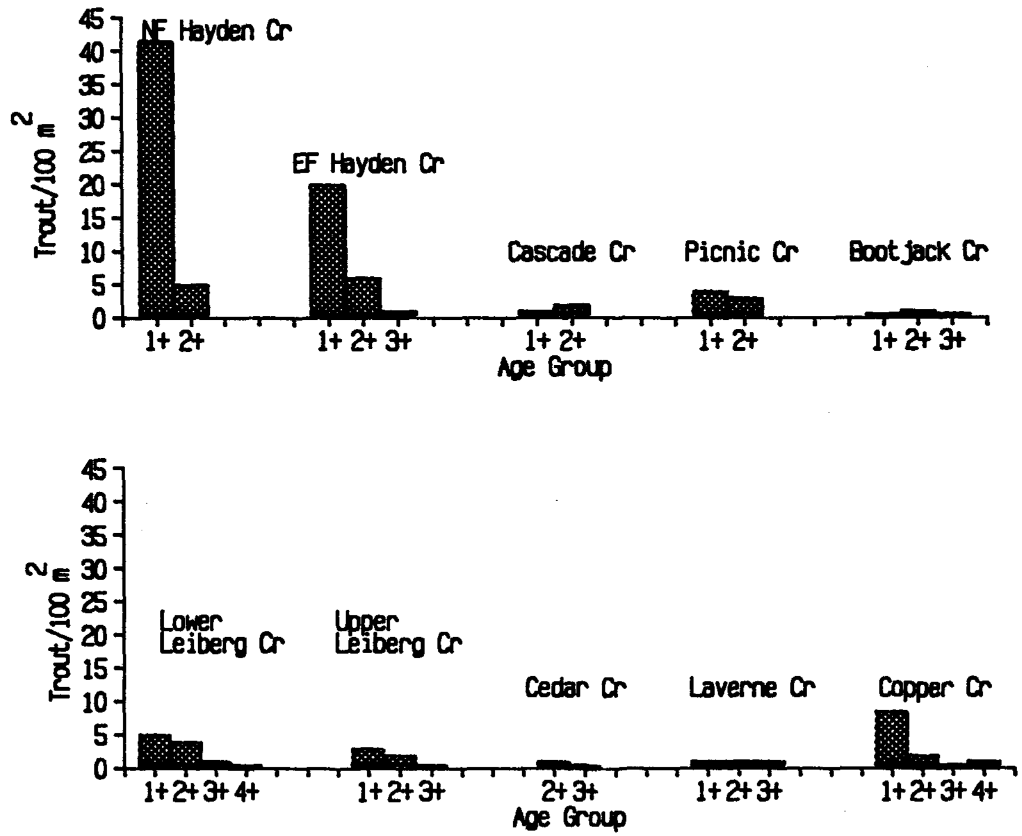


Figure 6-a. Mean age group densities (per 100 m^2) from snorkel observations of Taft-Bell study streams, northern Idaho, 1985.

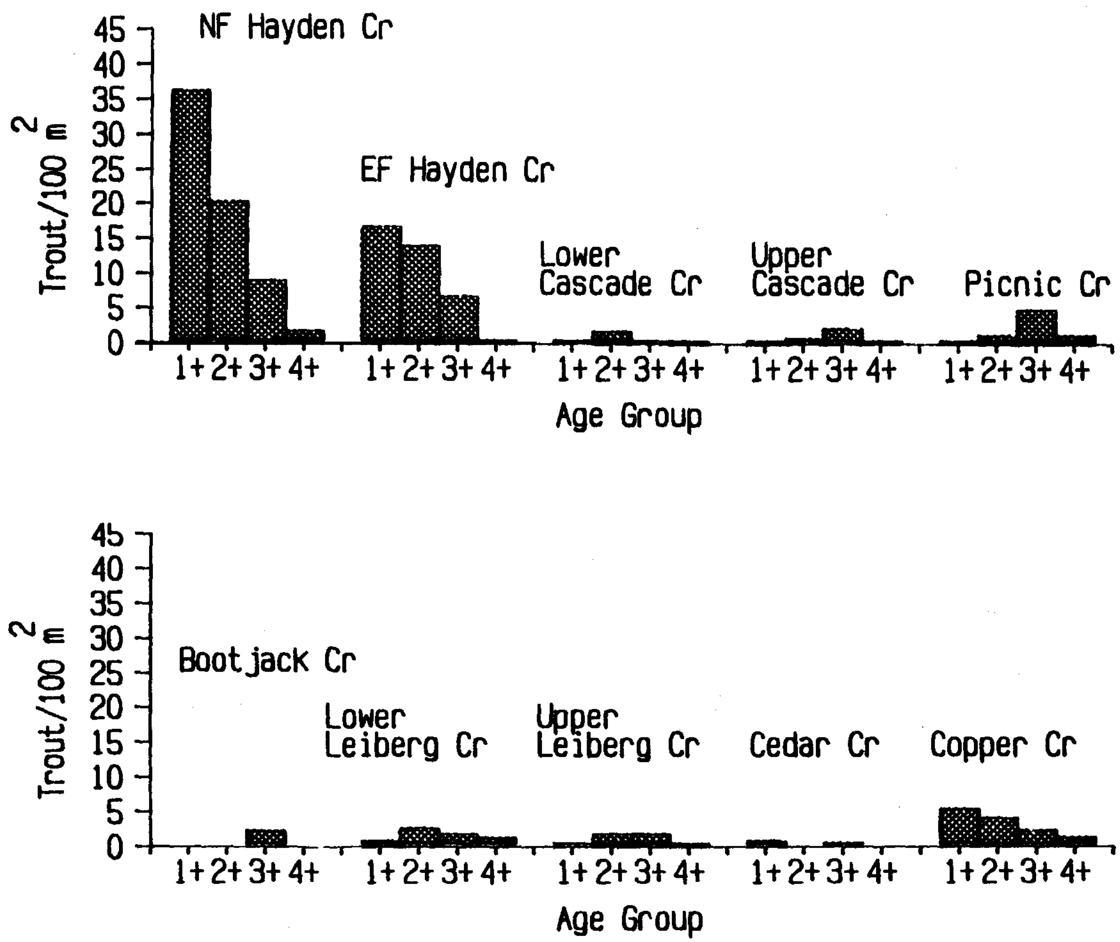


Figure 6-b. Mean age group densities (per 100 m^2) from snorkel observations of Taft-Bell study streams, Northern Idaho, 1986.

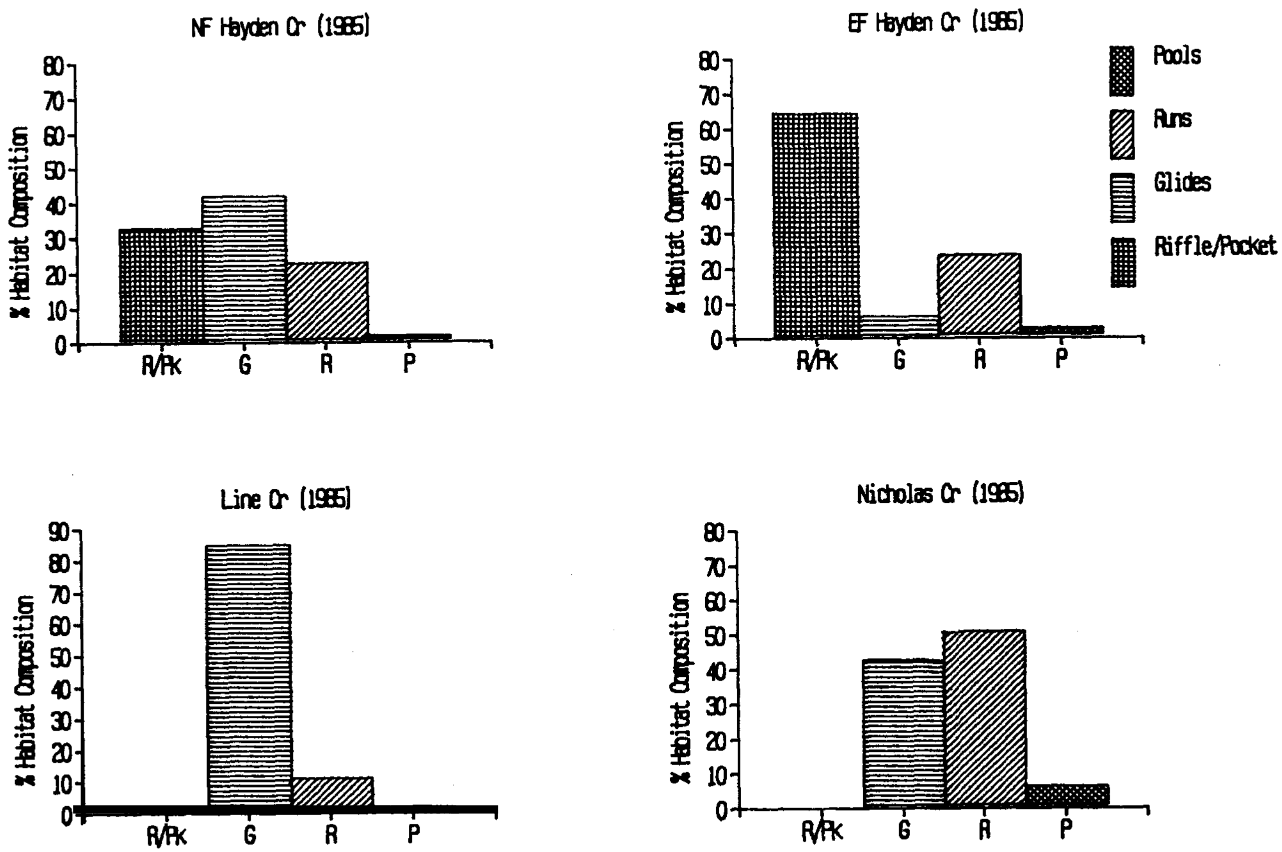
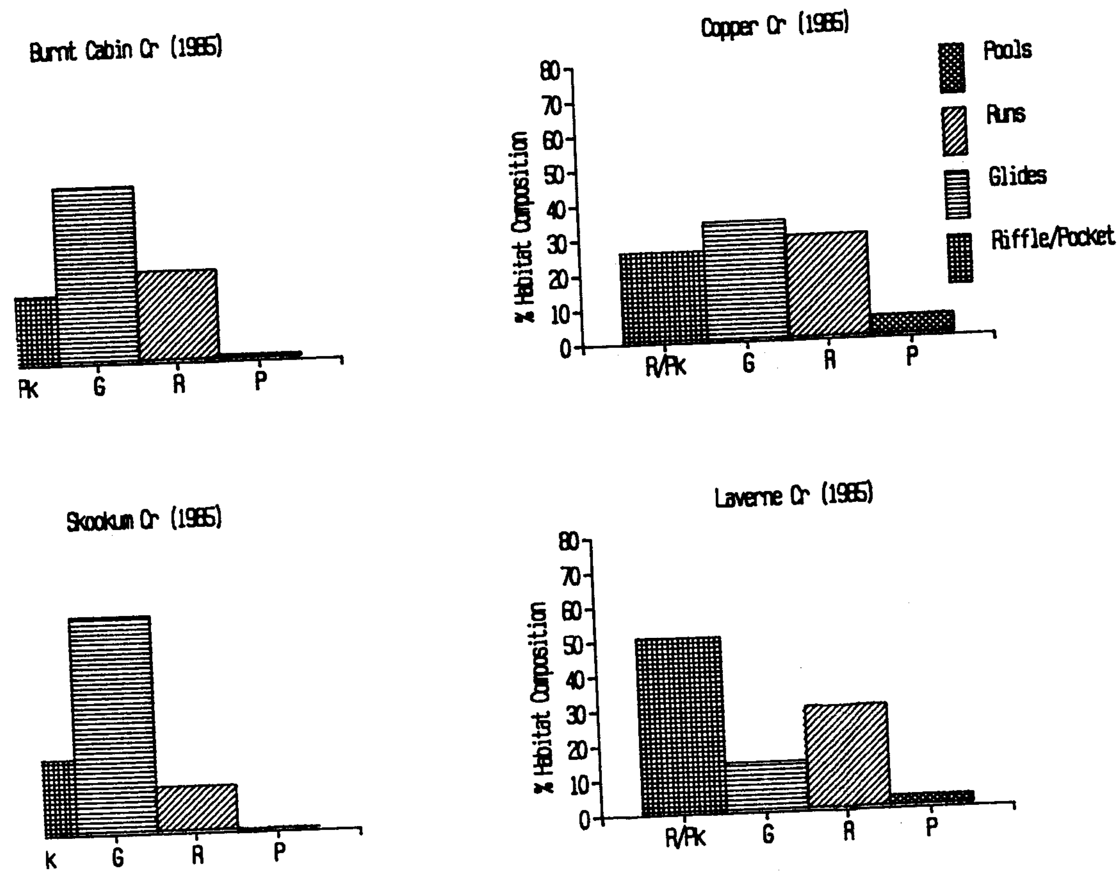


Figure 7. Habitat composition of representative Taft-Bell study streams, northern Idaho, 1985.



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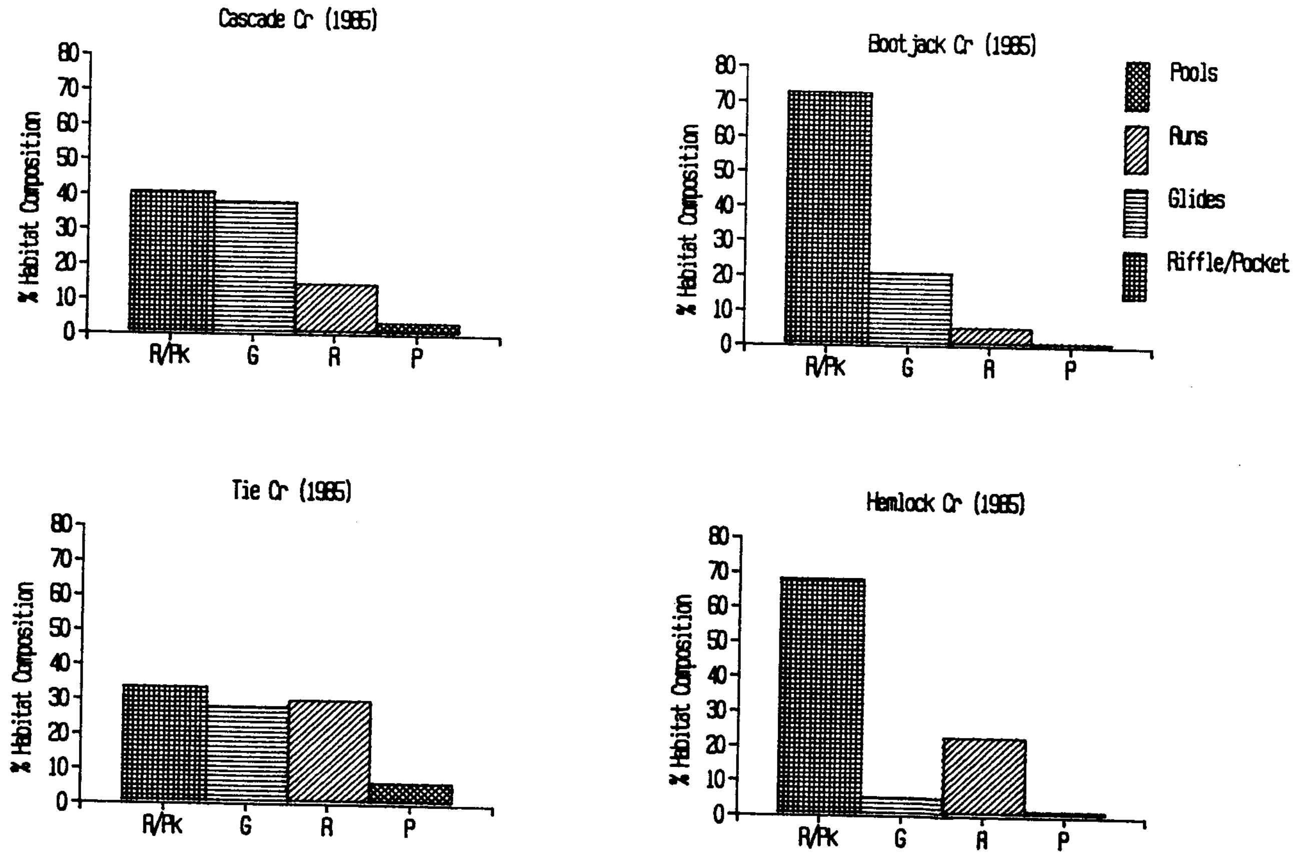

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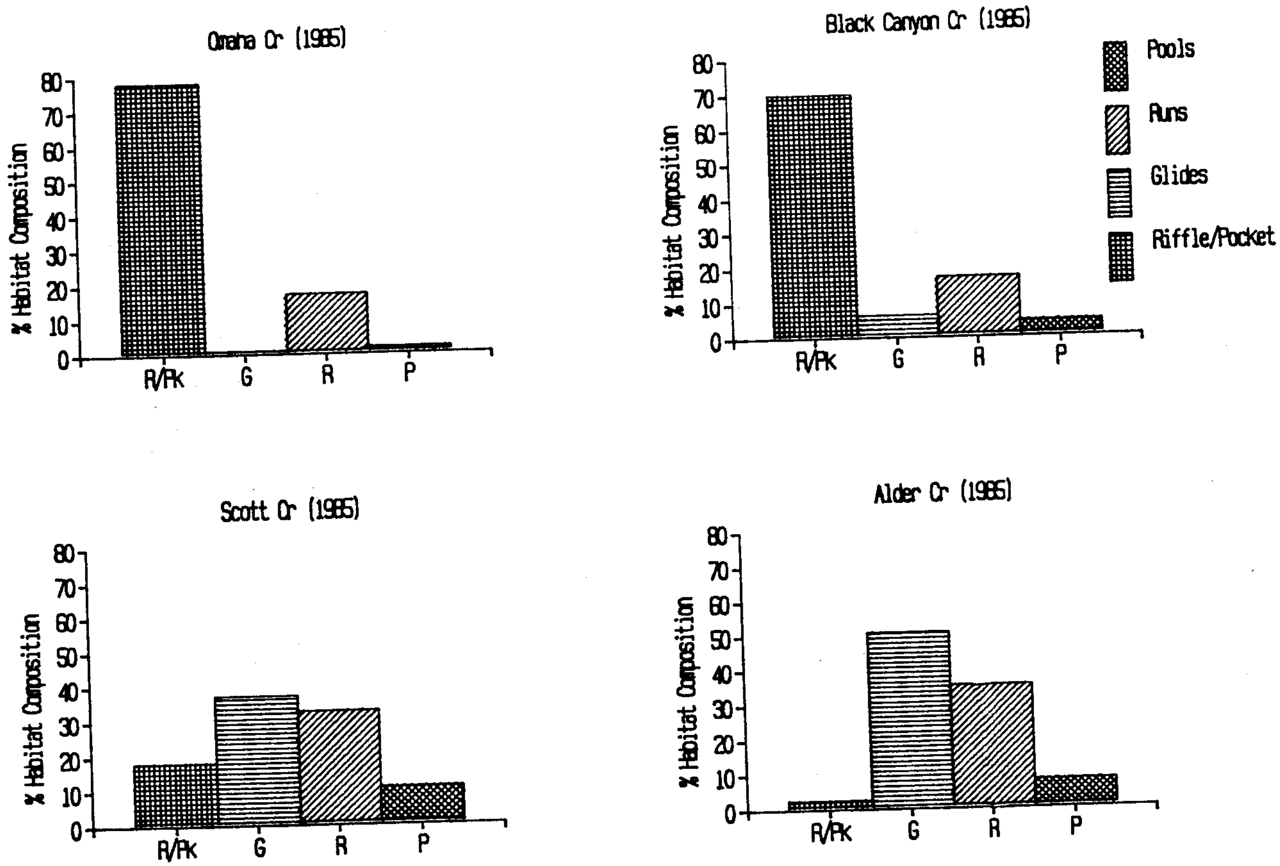

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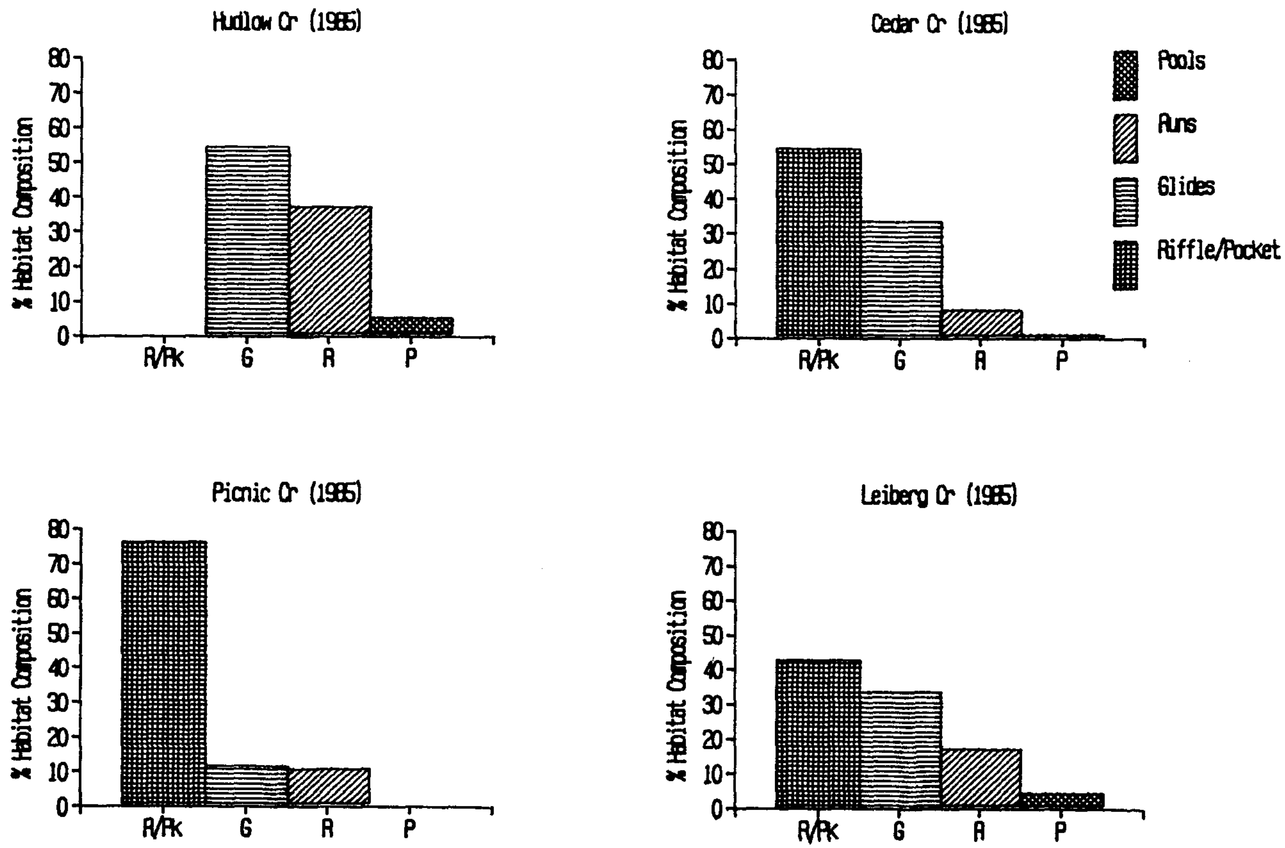

Figure 7, continued.

Substrate Composition

Fine Sediments

Summary statistics from the analysis of sediment samples are presented in Appendices C and D. In 1985, percentages of sediment samples less than 6.4 mm in diameter varied among the study streams from approximately 152 in Picnic Creek to 401 in Laverne Creek and averaged 242. In 9 of the 21 study streams, sediment less than 6.4 mm in diameter comprised more than 252 of the substrate. The remaining streams varied from 15 to 202 of substrate less than 6.4 mm in diameter. Our 1986 samples had similar distributions, with the same trends apparent among study streams for high and low percentages and number of streams with greater than 252 fines.

Substrate Embeddedness

Cascade and Omaha creeks had the highest substrate embeddedness percentages (36% in 1985 and 24% in 1986, respectively). Hudlow and the East Fork of Hayden Creek had the lowest substrate embeddedness (16% each in 1985 and 1986, respectively). As expected, there is an inverse relationship between percent embeddedness measurements and percent free particle observations. The percentage of free particles was greatest in Hudlow Creek, 612 and 672 during both years, and lowest in Cascade (27%) and Omaha (512) creeks during 1985 and 1986 (Table 6).

Embryo Survival

Predictions of cutthroat trout embryo survival-to-emergence by the Tappel method and the Fredle index regression equation differed substantially for both 1985 and 1986 data (Table 7). The Fredle method consistently predicted lower survival percentages than the Tappel method did for identical sediment samples. In 1985, the predictive differences between methods ranged from 172 to 461 and averaged 301. During 1986, the spread of differences was 302 to 451, and the average difference was 38%. Black Canyon and Picnic creeks had the highest predicted embryo survival, 77% each in 1985 and 74% and 76%, respectively, in 1986 by the Tappel method. The highest embryo survival predictions by the Fredle method was for Picnic Creek, 372 in 1985; and Black Canyon Creek, 42% in 1986. The low predictions for both methods were for Laverne Creek (272 in 1985) and Scott Creek (48% in 1986) by the Tappel method; and Laverne Creek (10% in 1985; 17% in 1986) by the Fredle method.

Control vs. Treatment Observations

Control transects for trout density and sediment distribution measurements were established in upper Cascade and Leiberg creeks. Trout densities and sediment distributions from control and treatment sections are contrasted in Tables 8-9. Sediment samples were not collected in 1985

Table 6-a. Mean substrate embeddedness statistics for Taft-Bell monitoring streams, northern Idaho, 1985.

Stream	Percent embeddedness	Percent free particles
Alder	31	39
Cedar	19	60
Scott	24	54
Omaha	25	46
Black Canyon	19	59
Copper	20	61
Laverne	26	49
Leiberg	29	44
Hemlock	26	52
Tie	20	56
Bootjack	24	51
Smith	21	51
Skookum	29	35
Picnic	20	61
Cascade	36	27
Burnt Cabin	23	55
Nicholas	24	36
Hudlow	16	66
E. Fk. Hayden	28	45
Line	19	65
N. Fk. Hayden	34	28

Table 6-b. Mean substrate embeddedness statistics for Taft-Bell monitoring streams, northern Idaho, 1986.

Stream	Percent embeddedness	Percent free particles
Alder	23	54
Cedar	19	59
Scott	17	62
Omaha	24	51
Black Canyon	20	58
Copper	14	73
Laverne	19	54
Leiberg	21	55
Hemlock	21	59
Tie	19	60
Bootjack	20	56
Smith	--	--
Skookum	14	68
Picnic	16	64
Cascade	21	61
Burnt Cabin	21	62
Nicholas	18	64
Hudlow	17	67
E. Fk. Hayden	16	66
Line	20	62
N. Fk. Hayden	18	62

Table 7-a. Mean percent cutthroat trout embryo survival-to-emergence estimates by the Tappel and Fredle methods for Taft-Bell monitoring streams, northern Idaho, 1985.

Stream	Mean percentage survival		
	Tappel estimate	Fredle estimate	Difference
Black Canyon	79	31	48
Picnic	77	37	40
Omaha	64	26	38
Cascade	60	21	39
Line	59	25	34
Nicholas	57	19	38
Alder	54	24	30
Leiberg	51	17	34
Hudlow	50	18	32
Skookum	50	29	21
Copper	48	20	28
E. Fk. Hayden	43	15	28
Tie	42	17	25
N. Fk. Hayden	41	15	25
Cedar	39	21	18
Bootjack	37	27	10
Scott	28	12	16
Laverne	27	10	17
Hemlock	57	18	39

Table 7-b. Mean percent cutthroat trout embryo survival-to-emergence estimates by the Tappel and Fredle methods for Taft-Bell monitoring streams, northern Idaho, 1986.

Stream	Mean percentage survival		
	Tappel Estimate	Fredle Estimate	Difference
Black Canyon	74	42	32
Picnic	76	31	45
Omaha	58	20	38
Cascade	62	25	37
Line	55	20	35
Nicholas	54	20	35
Alder	54	20	34
Leiberg	54	18	36
Hudlow	68	27	42
Skookum	71	30	41
Copper	56	24	32
E. Fk. Hayden	61	21	40
Tie	55	17	37
N. Fk. Hayden	59	21	38
Cedar	80	35	45
Bootjack	77	37	41
Scott	48	17	30
Laverne	55	19	36
Hemlock	68	25	43

Table 8-a. Mean values by reach for trout densities (fish/100 m^2) in control and treatment transects of Cascade Creek, northern Idaho, 1985 and 1986.

Year	Fish densities (per 100 m^2) fry in parentheses Transect number 1		2		3		4		5	
					Control Transects					
1985					No data collected					
1986	5.2	--	9.3	--	2.2	(6.7)	3.1	(6.2)	2.2	--
					Treatment Transects					
1985	10.0	(4.3)	1.2	(2.3)	2.0	--	--	--	--	--
1986	3.5	(1.2)	7.4	--	5.5	--	1.0	--	--	--

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Table 8-b. Mean values by reach for trout densities (fish/100 m^2) in control and treatment transects of Leiberg Creek, northern Idaho, 1985 and 1986.

Year	Fish densities (per 100 m^2) fry in parentheses Transect number 1		2		3		4		5	
					Control Transects					
1985	1.3	(1.3)	--	(8.5)	1.7	--	14.6	(1.9)	3.2	(6.4)
1986	6.6	(1.7)	11.8	(2.0)	1.7	--	--	--	1.6	--
					Treatment Transects					
1985	11.8	(1.7)	3.1	(6.8)	18.0	(9.9)	15.8	(4.7)	4.6	(4.6)
1986	7.2	--	7.6	--	12.1	--	11.7	--	3.9	--

Table 9-a. Mean values by reach for sediment distribution in control and treatment transects of Cascade Creek, northern Idaho, 1985 and 1986. Letter codes designate stream reaches within treatment and control stream sections.

					Percentage of fine substrate				
Reach	n	so	dg	fi	<0.8 mm	<9.5 mm	<6.4 mm	Tappel	Fredle
					Control, 1985				
A					No data collected				
B									
					Control, 1986				
A	7	3.0	13.4	4.5	2	40	28	52.3	21.5
B	7	2.8	14.0	4.9	0	37	25	67.2	23.8
					Treatment, 1985				
A	5	3.0	13.4	4.6	6	32	20	34.5	22.0
B	5	2.9	18.3	6.4	7	33	23	29.3	31.7
C	5	3.5	8.5	2.5	2	44	29	49.9	10.6
					Treatment, 1986				
A	5	2.6	15.6	6.0	0	30	18	70.3	29.4
B	5	3.3	17.2	5.2	1	27	21	69.3	25.4
C	5	3.2	16.0	5.1	2	33	26	51.9	24.6

Table 9-b. Mean values by reach for sediment distribution in control and treatment transects of Leiberg Creek, northern Idaho, 1985 and 1986. Letter codes designate stream sections within treatment and control stream sections.

					Percentage of fine substrate				
Reach	n	so	dg	fi	<0.8mm	<9.5mm	<6.4mm	Tappel	Fredle
					Control, 1985				
A					No data collected				
B									
					Control, 1986				
A	7	3.3	11.0	3.4	1	42	31	52.2	15.3
B	7	3.1	10.2	3.3	1	47	35	47.5	15.2
C	6	3.4	12.4	3.6	4	38	28	42.3	16.7
					Treatment, 1985				
A	3	3.5	6.8	2.0	4.3	60.1	48.3	19.7	7.7
B	5	3.4	16.7	4.9	1.4	29.5	23.4	65.9	23.8
C	7	3.5	14.0	4.0	2.0	38.3	29.5	53.7	18.9
					Treatment, 1986				
A	5	3.3	14.4	4.4	1	35	25	57.5	21.0
B	4	3.4	13.5	4.0	2	34	26	51.7	18.5
C	4	3.2	13.7	4.3	1	36	27	66.5	20.0

from the Leiberg Creek control section, and neither fish density estimates nor sediment samples were collected from the Cascade Creek control section in 1985.

Trout densities in the Cascade Creek control section were higher than the treatment section, while the reverse was true for Leiberg Creek. These differences appear to reflect habitat differences between the stream sections.

The composition of sediment samples from control and treatment sections in each stream are similar, with no distinct differences in either percent fines or textural composition.

Spring Migrant Monitoring

Ten streams were sampled from April through June 1986 with a portable fyke net trap to identify the most significant streams for production of migrant cutthroat trout. Results of those efforts are shown in Table 10. The North and East forks of Hayden Creek, important spawning and rearing tributaries for Hayden Lake adfluvial cutthroat trout, were included as sample streams for comparison with lesser known streams. The greatest number of migrant juvenile cutthroat trout were captured in Leiberg, Picnic and the North Fork of Hayden creeks. The mean length of migrant juveniles among sample streams ranged from 94-158 mm, lengths consistent with expected size groups of migrant adfluvial and fluvial juvenile cutthroat trout. Catch per unit effort was highest in the North Fork of Hayden Creek, Leiberg Creek and Picnic Creek.

Trout Density-Sediment Relationships

Results of regression analysis of trout densities and five measures of stream substrate quality indicate there is no relationship between either the textural qualities of stream substrates or the amounts of fine sediments and trout abundance in our study streams.

Regressing trout densities against percent embeddedness, percent free particle incidence, predicted embryo survival percentages and percent sediment less than 6.4 mm in diameter (Appendices D-G) resulted in low r^2 values and nonsignificant regression coefficients for each comparison (Figures 8-12).

On-Site Monitoring

1985 Observations

We monitored three Taft-Bell related instream construction activities during 1985. Early road pioneering and culvert placement work was accomplished in the Beaver Creek drainage, Wallace Ranger District. This work crossed Alder Creek, tributary to Beaver Creek, one of our study

Table 10. Results of stream trapping efforts for downstream juvenile trout migrants in selected tributaries of the North Fork Coeur d'Alene River, northern Idaho, April to June, 1986.

Stream	Number nights fished	Number hours fished	Number trout caught	Mean length (mm)	CPUE
Scott	1	3	0		0
Laverne	3	60	3	120	0.05
Copper	4	80	1	158	0.01
Leiberg	4	90	17	115	0.19
Bootjack	1	20	0		0
Picnic	3	66	8	140	0.12
Cascade	3	69	4	94	0.06
Burnt Cabin	1	23	2	152	0.09
E. Fk. Hayden	1	23	2	152	0.09
N. Fk. Hayden	1	21	16	133	0.76

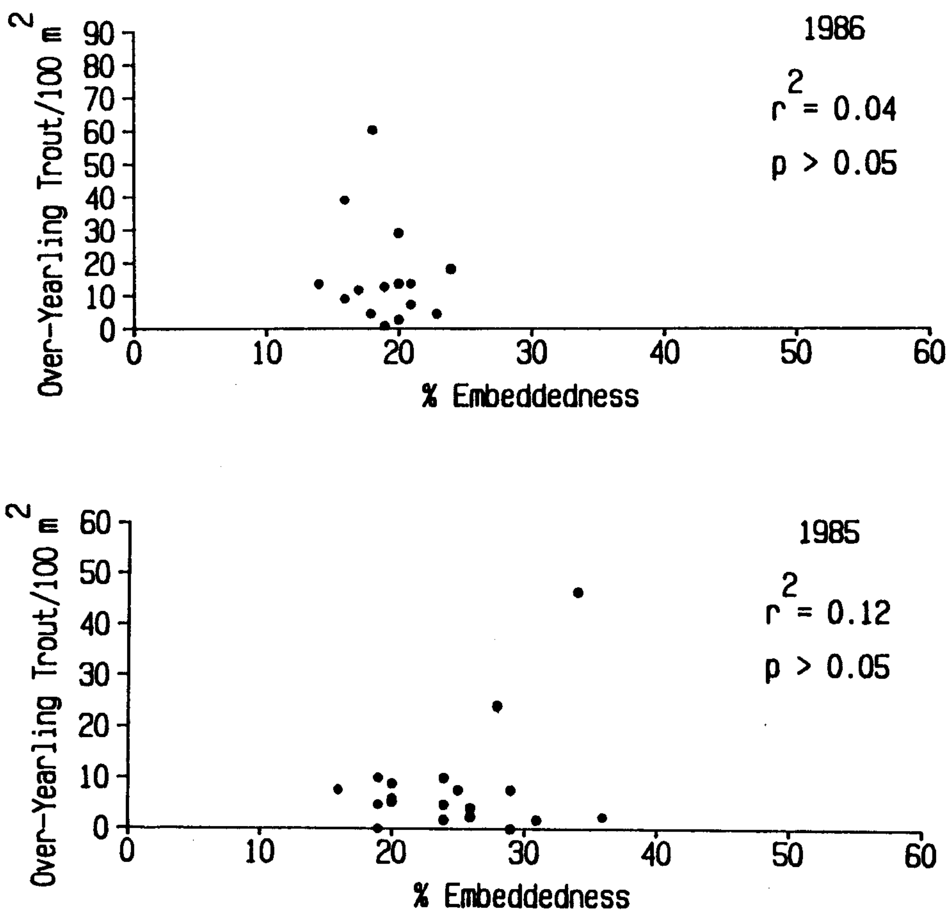

Figure 8. Relationship between percent particle embeddedness and overyearling trout densities in Taft-Bell study streams, northern Idaho, 1985-1986.

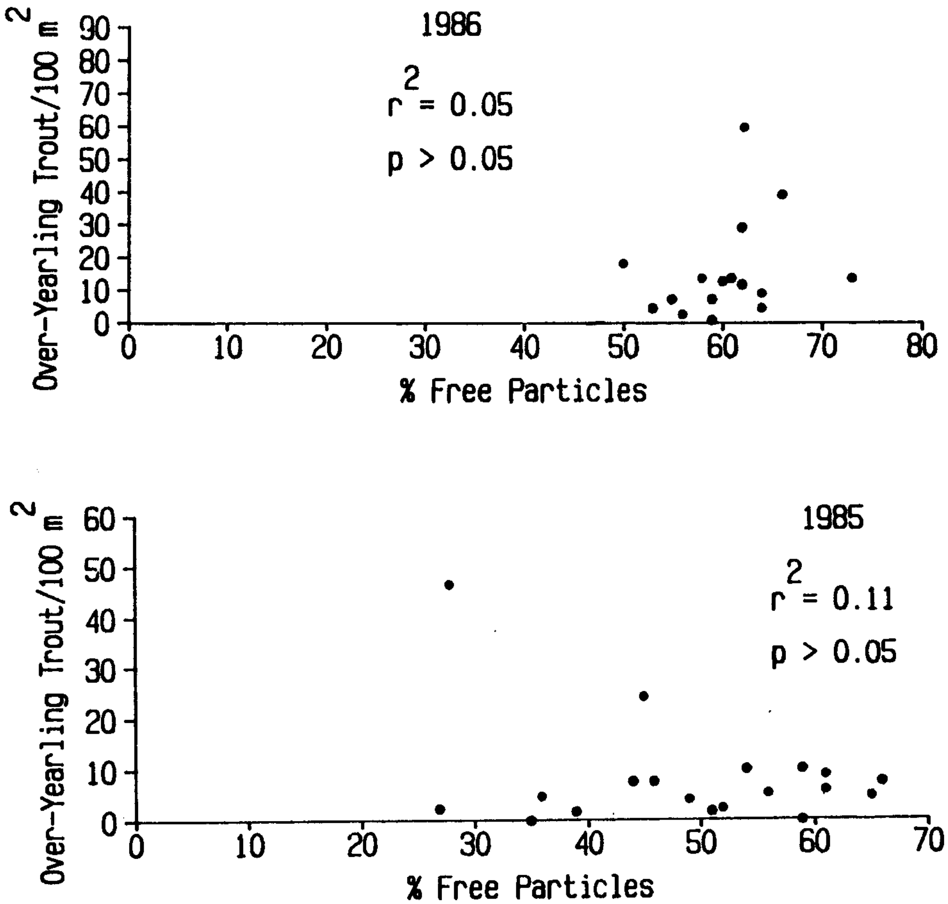

Figure 9. Relationship between percent free particles and overyearling trout densities in Taft-Bell study streams, northern Idaho, 1985-1986.

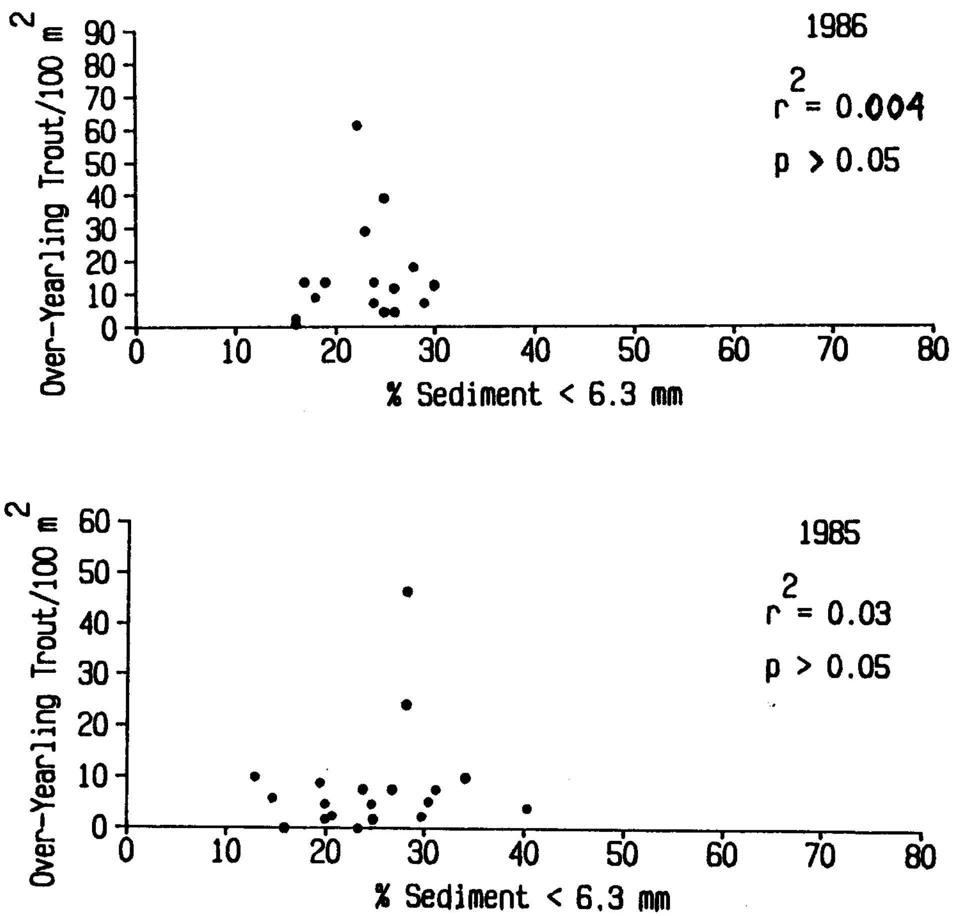

Figure 10. Relationship between percent sediment less than 6.3 mm in diameter and overyearling trout densities in Taft-Bell study streams, northern Idaho, 1985-1986.

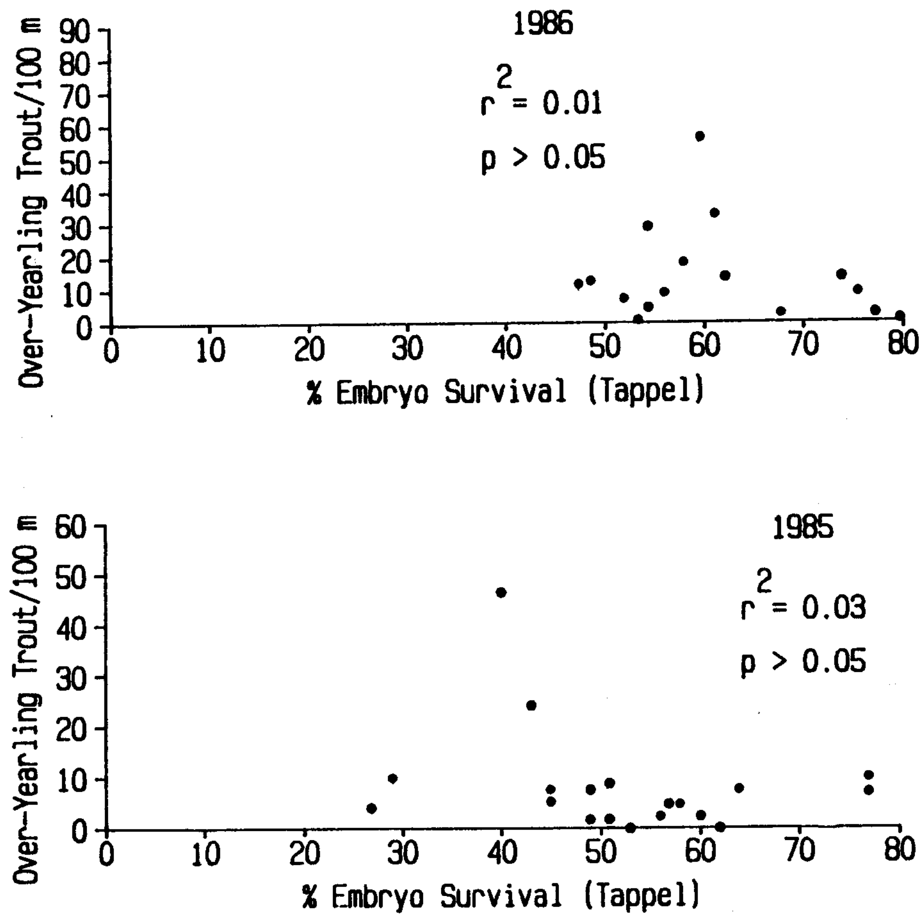

Figure 11. Relationship between predicted embryo survival (Tappel method) and overyearling trout densities in Taft-Bell study streams, northern Idaho, 1985-1986.

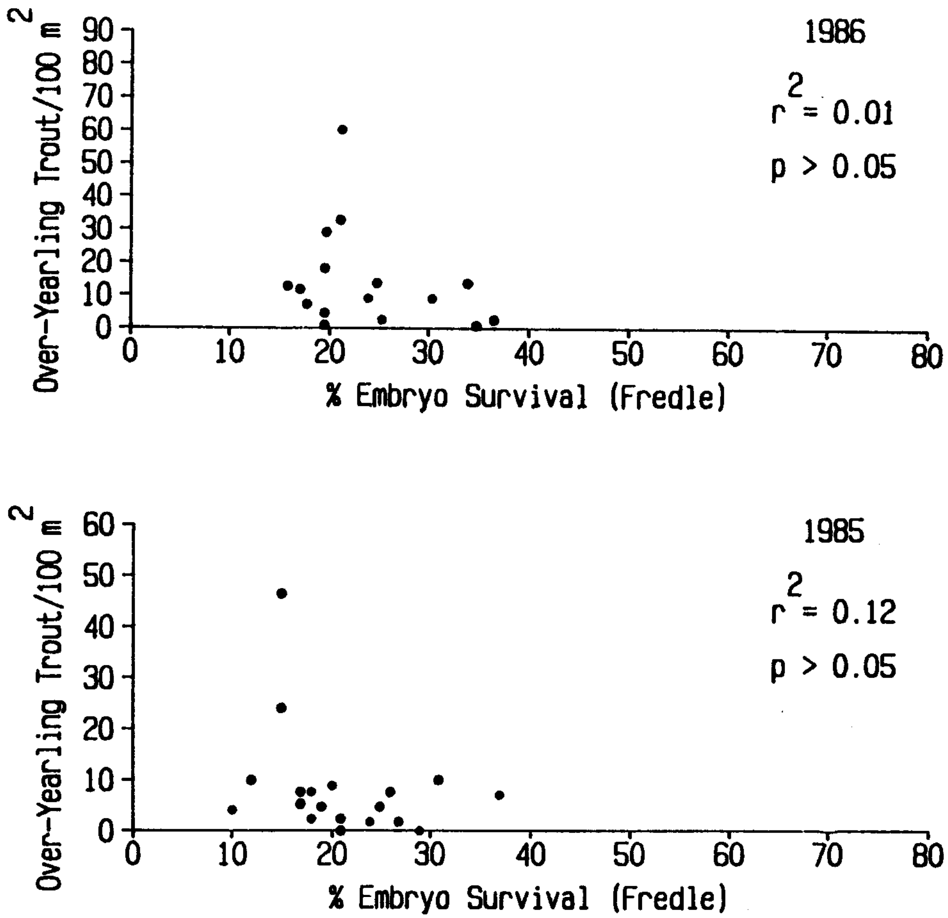

Figure 12. Relationship between predicted embryo survival (Fredle method) and overyearling trout densities in Taft-Bell study streams, northern Idaho, 1985-1986.

streams. Culvert replacement work occurred on the North Fork of Hayden Creek, and stream channel alteration work was performed below a culvert on Canyon Forks Creek to improve fish passage. We made three visits to each site during construction activities to establish photo points, take photos and record observations of cut-and-fill slopes, bank stability, entry of sediments into the stream and any other pertinent observations. The culvert crossing on Alder Creek was high in the drainage above flowing water at that time of year. Cut-and-fill slopes above and below the crossing were filter windowed. We did not observe sediments from the road construction work in the stream channel at that time. Likewise, our observations at the North Fork Hayden Creek and Canyon Forks Creek crossings indicated no addition of appreciable amounts of sediment.

1986 Observations

The majority of the Taft-Bell construction work was conducted in 1986. During that phase of the project, we identified four problem areas where Taft-Bell construction activities caused sediment additions to study streams.

In late June during heavy rains, an improperly placed road dip in Forest Road #6904 resulted in overland flow from the road down a fresh fill slope and into Tie Creek. This erosion occurred over a period of several days and noticeably discolored the stream flow below its entry into the stream. The BPA contractor corrected the problem by reconstructing the road dip and constructing a settling basin below the runoff source within the week. This incident occurred after our core sampling in Tie Creek. Consequently, those sediment additions are not reflected in our 1986 sediment data.

In July on Forest Road #961, a BPA contractor working on a road crossing on a tributary to Scott Creek improperly operated heavy equipment in the stream channel. This pushed a large amount of loose fill soil into the stream channel and did damage to the stream channel itself. This damaged area was later stabilized with loose straw; however, retrieval or stabilization of the loose sediment in the channel was not possible. It is doubtful that sediment from this source site was transported into the main Scott Creek channel in 1986. The tributary this occurred in has good sediment storage capacity (primarily by large, woody debris), but most of the sediment was loose fine material that will eventually make its way into the Scott Creek channel. Our 1986 sediment sampling was completed before this incident also.

In September, a BPA-contracted rock-crushing operation adjacent to Cascade Creek (off Forest Road #379) experienced a temporary breach in a retaining wall between Cascade Creek and the excavation pit, which had collected sediment-laden water. An unknown quantity of fine sediment was discharged into lower Cascade Creek from this event, again after our 1986 sediment sampling was complete.

In November during heavy rains, work on Forest Road #1528 in the Todd Creek drainage (tributary to the East Fork of Hayden Creek) caused a section of that road to slump into Todd Creek. The stream channel was choked with fine sediment and moved laterally several yards from its course prior to the road slump. The section of stream affected by the road slump is approximately 30 yards in length. Personnel from BPA, their contractor, the IPNF and IDFG met at the site to review the situation and agreed on methods to stabilize the slump. Forest Service and BPA contracting personnel installed rock and straw bale retaining walls, between the road and stream channel, to hold back any further creep of soil into the channel. The fill slope from the road to the stream channel was also seeded to stabilize the surface of the slope. The disturbance site on Todd Creek is at least one-quarter of a mile above the East Fork of Hayden Creek. Movement of that sediment through Todd Creek into the East Fork of Hayden Creek will take time, but should be detected by sediment sampling if it significantly increases fine material in the mid-sampling reach of the East Fork of Hayden Creek.

Two other potential sediment sources to study streams were identified. During November and December 1986, a rock-crushing operation near lower Hayden Creek off Forest Road 1437 contributed a substantial amount of sediment runoff to the Hayden Creek floodplain, but did not reach the stream channel itself. Additionally, Forest Road #1526 adjacent to Line Creek was widened such that the new fill slope toe extends almost to the stream channel in several places. There is little margin for error should the fill slope destabilize at any of those points.

DISCUSSION

This phase of the monitoring study was intended to design and implement the entire ten-year project. Because our role has been specialized and preliminary, the data we present here should be interpreted as preconstruction observations. As such, these data do not yet provide a basis for evaluating actual effects of the Taft-Bell construction project on trout habitat or trout populations in impacted streams. The evaluation of what, if any, effects Taft-Bell will have on cutthroat trout populations should be deferred until an adequate database is compiled over the full term of the study. Because of the dynamic relationship between stream-dwelling trout populations and their environment, a long-term database is necessary to adequately describe population responses to environmental changes. Burns (1971) attempted to evaluate the carrying capacity of northern California streams for juvenile salmonids. He concluded that even with three years of baseline data, he could not attribute changes in carrying capacity under 50% to anything but natural variation.

The role of this report is to characterize the nature of the trout populations, the trout habitat and the sediment distribution in Taft-Bell study streams. With that perspective, it will be possible to anticipate what effects the Taft-Bell project might ultimately have on those stream resources and to recommend how best to evaluate the Taft-Bell project for its effect on the fishery resource.

Substrate Characteristics

The amounts of fine sediment we observed in most of our study streams are low or moderate relative to deleterious levels of fine sediment reported by previous investigators. McCuddin (1977) found that survival-to-emergence of chinook salmon Oncorhynchus tshawytscha and steelhead trout Salmo gairdneri embryos decreased sharply when their substrate environment was comprised of more than 20 to 25% sediment smaller than 6.4 mm in diameter. He recommended that Idaho Batholith streams be managed to limit the amount of sediment less than 6.4 mm in diameter to 25% or less to protect spawning habitat. Only 9 of the 21 streams we sampled in 1985 and 1986 had more than 25% sediment less than 6.4 mm in diameter. Koski (1975) noted reductions in intragravel dissolved oxygen and chum salmon Oncorhynchus keta embryo survival when sediment less than 3.3 mm in diameter exceeded 35% of spawning substrate. If expanded to include all material under 6.4 mm (rather than 3.3 mm) in diameter, that threshold of fine sediment composition would have been greater than 35%. Koski's observations of limiting levels of fine sediment are well above the 25% limit recommended by McCuddin (1977) and the levels we observed in our study streams. The low levels of fine sediment we have observed are consistent with that expected from the geologic parent material these stream sediments are derived from. The Belt Series are comparatively unweathered, nonerosive soils which contribute large particles in greater proportion to fine sediment particles (Jerry Neihoff, IPNF soils scientist, personal communication; USFS unpublished flood damage report 1974).

Substrate particle embeddedness measurements also reflect the low levels and negligible influence of fine sediment on trout production in the study streams. Unpublished data, collected from the South Fork of the Salmon River (central Idaho), were used by D. Burns and R. Thurow to develop a general relationship between particle embeddedness and densities of age 0 and age 1 chinook salmon, steelhead and cutthroat trout (Burns, personal communication). They found that salmonid densities were inversely related to particle embeddedness (r^2=0.38; regression coefficient significant at $p=0.01$). As a general rule, they observed that high salmonid densities did not occur where embeddedness exceeded 35-40%, but did when embeddedness levels were below 30-35%. Our data indicate that particle embeddedness in Taft-Bell study streams is well below a 30% threshold (1985: maximum=36%, minimum=16%, mean=241; 1986: maximum-24%, minimum-14%, mean=19X; Table 7). The relationships reported by Burns and Thurow are subject to a variety of confounding factors including stream order, gradient, species response and seeding levels (Chapman 1987). Regardless of those shortcomings, their data represent the best understanding of fish densities at high embeddedness levels in Idaho streams and do provide a good comparison for our data. The relatively low percentages of fine sediment and substrate embeddedness are also reflected in the low r^2 values from the regressions of fine sediment and embeddedness on trout densities. The absence of statistically significant relationships between trout densities and fine sediment measurements, or indices, is a compelling indication that under current conditions, fine sediment is not limiting trout production in our study streams. Factors other than fine sediment are limiting trout production at this time.

Trout Abundance

In spite of the relatively low levels of both fine sediment and substrate particle embeddedness, the trout populations we studied are depressed. The majority of streams we surveyed have trout densities below those of less disturbed northern Idaho streams of similar size, water quality and angling pressure. The larger densities of cutthroat trout in Hayden Creek are exceptions which I attribute to a combination of higher seeding levels and better rearing habitat than occur in most Coeur d'Alene River tributaries. Virtually all of the natural production of wild trout in Hayden Lake is dependent on Hayden Creek, due to the loss of spawning and rearing habitat in other Hayden Lake tributaries. The high quality of spawning and rearing habitat in Hayden Creek and its exclusive nature to Hayden Lake as a spawning and rearing tributary assure Hayden Creek of large annual spawning escapements and juvenile trout densities. Those circumstances do not occur in any of the other Taft-Bell study streams.

The common denominator among streams with low numbers of trout (<5/100 m^2) is poor rearing habitat associated with a lack of instream structure (large organic debris, boulders and other roughness elements) and excessive deposits of large bedload sediment. Those streams which had higher densities of trout (e.g., Leiberg and Copper creeks) also had combined pool, run, and glide habitat percentages equal to or greater than riffle/pocket water percentages. Even though our stream habitat data are not extensive enough to allow a firm statistical analysis, a trend is apparent between percentages of "preferred" trout rearing habitat (pools, runs and glides) and trout densities.

While the amounts of fine sediment in Coeur d'Alene River and Hayden Creek tributaries are below levels expected to limit trout production, the total sediment transport in these streams is an apparent problem. Transport of large bedload sediment (gravel to cobble size material) in these streams is high, and the sediment storage capacity, determined by roughness elements such as fallen trees, root wads or boulders, is low. The scarcity of large roughness elements and attendant-unchecked transport of large aihounts of sediment has resulted in low percentages of pools, runs and instream cover, critical elements of salmonid rearing habitat in many northwest rivers and streams (Sullivan et al. 1987; Bisson et al. 1987). Most Taft-Bell study streams are dominated by shallow riffle and pocket water structure less desirable as trout rearing habitat. These streams are characterized by shallow, wide stream channels with uniform bottoms and very low pool to riffle ratios. A one to one ratio of pools to riffles is generally cited as the convention for good trout habitat (Platts et al. 1983). Stream channel and substrate diversity are important components of good salmonid habitat and are dependent on roughness elements (logs, root wads or boulders) which provide hydraulic controls and regulate sediment movement through stream channels (Sullivan et al. 1987; Lisle 1983; Bilby 1984; Megahan 1976). These key roughness elements, crucial to the maintanence of good spawning and rearing habitat, are low in abundance in the majority of the study streams. Rearing habitat is generally in short supply in Taft-Bell study streams and currently may be the primary determinant of trout densities in those streams.

Continuation of Taft-Bell Monitoring

For the remainder of the monitoring study, several recommendations are offered.

The original monitoring proposal called for Forest Service personnel to monitor study streams every other year for the duration of the ten-year project. A review of the on-site monitoring, trout density and migrant trapping information we collected indicates that some study streams should be monitored every year. Taft-Bell construction activities resulted in either direct or potential sediment recruitment to Scott, Tie, Leiberg, East Fork Hayden and Line creeks. Each of those streams also had high trout densities relative to other study streams. Leiberg and Hayden creeks had the highest apparent rates of juvenile cutthroat migration. Yearly monitoring will provide a more adequate assessment of Taft-Bell impacts on those important streams.

The wide differences between the survival-to-emergence predictions by Tappel and Fredle methods make it necessary to select only one of the two methods for future use. Considering the relatively poor fit (r^2=0.74) between the embryo survival rates and Fredle numbers from which the Fredle predictive equation was derived (Appendix B), the Tappel equation should be considered the more reliable of the two methods. By contrast, the predictive equation used by the Tappel method accounted for 94% of the variance in embryo survival during its development trials. The poorer performance by the Fredle predictive equation and the disparity between our Fredle and Tappel survival predictions suggest that further research will be required to adequately describe the relationship between intragravel embryo survival and Fredle numbers. The Fredle method will continue to provide a useful index of changes in the textural composition of streambed sediments. For example, a decline in Fredle values over time within a sample section would indicate an increase in intragravel fine sediments and a potential decline in substrate spawning suitability. I also recommend the continued use of stream sediments less than 6.4 mm in diameter as a measure of change in abundance of this detrimental class of fine particles.

Substrate embeddedness measurements should not be used to evaluate the quality of stream gravels as trout spawning habitat because the technique is not a sensitive measure of the vertical distribution of streambed sediments. Knowing how sediments are distributed vertically is essential to understanding the effects of those sediments on embryo survival (Lotspeich and Everst 1981). Embeddedness measurements do, however, yield useful data to monitor changes in fine sediment recruitment (significant increases in fine sediments should increase embeddedness measurements) and may serve as a useful index of invertebrate habitat and overwintering habitat for salmonids. Invertebrate production and the salmonid overwintering capacity of streambeds are both inversely related to substrate embeddedness (Bjornn et al. 1977). Previous investigators (Lewynsky and Bjornn 1983) have speculated that overwintering habitat may be a limiting environmental factor for cutthroat trout in the North Fork Coeur d'Alene River drainage. Embeddedness measurements should be continued to monitor both sediment recruitment to the study streams and habitat suitability for invertebrates and overwintering trout.

In order to determine whether significant changes to stream resources have occurred after completion of the Taft-Bell project, I recommend that statistical comparisons of both trout densities and stream sediment data be employed.

Small sample sizes for trout densities within stream and between year comparisons will preclude the use of parametric statistical tests. For comparison of trout densities between two years, a Mann-Whitney U nonparametric test should be employed. For the comparison of trout densities among several years, the Kruskal-Wallis nonparametric test will be more appropriate than an analysis of variance.

Within stream, between year comparisons of percent sediment less than 6.4 mm in diameter, Fredle numbers, geometric mean values or percent embeddedness values may be appropriate by conventional parametric tests, such as the group comparison t-test and analysis of variance. The use of parametric tests would depend on satisifying important assumptions, such as equality of variances, normally distributed populations, etc. If those tests may not be employed because test assumptions are not met, then the distribution-free tests (nonparametric) mentioned above may be employed in their place.

These tests may be employed on both pre- and postconstruction measurements and treatment versus control observations. Both categories of observations (temporal and spatial) should be compared in the same fashion within the constraints of sample size, data normality and other limitations of statistical tests. The effects or lack of effects to test for are the same in each case: increases in particle embeddedness and fine sediments, or decreases in predicted embryo survival and trout densities.

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APPENDICES

Appendix A. US Forest Service, Idaho Panhandle National Forest, stream habitat evaluation methods.

STREAM SURVEY INSTRUCTIONS

June 1987

The **primary objectives** in **performing stream surveys are:**

1. To identify existing stream habitat conditions: suitabilities, limiting factors, sensitivities;

2. To determine management needs: improvement projects, riparian treatments;

3. To assess the positive and negative effects of land management activities on a stream's carrying capacities.

The information collected should be compiled and interpreted within a riparian management plan which will provide long term direction (10 years) for the management of the stream and the associated riparian vegetation.

A stream survey begins by identifying stream reaches. A reach is a section of stream with the same potential for biological production and physical alteration. The stream length included in a reach should have a similar gradient (+ 1%), valley bottom and stream order. A reach should be at least 1/4 mile long. Initially streams should be divided into reaches using a topographic map but a more refined division will be possible when the stream is surveyed.

Streams are surveyed by walking each reach and recording data across 5 foot wide transects located 50 feet apart. For streams wider than 25 feet, 10 foot wide transects may be used at 100 foot intervals. In all cases, at least 10% 10% of a reach should be surveyed.

In addition to the survey forms, a topographic map should also be used to compile data. A map with a scale of at least 2.64 inches per mile is recommended. The following information should be noted on the map:

a) Stream reaches.
b) Trout migration barriers:

Full barrier:_______ FB	Culvert: C
Partial barrier:---- PB	Debris: D
Total barrier: T	Beaver: B
High water barrier: H	Falls: F
Low water barrier: L	Cascade: Ca

c) Debris jams needing treatment:
   If not a barrier: D ...
d) Beaver dams:
   If not a barrier: B ...
e) Slides, slumps, and other sediment sources:
   _____ S____
f) Significant channel braiding:
   Brd ---->
g) Dry lengths of the stream.
h) Specific riparian timber stands which correspond to the stand designation indicated on the survey form.
i) Segments of the stream actually surveyed if the stream is spot checked.
j) Any other feature which will be useful to locate.

FORM __1

Most recent form: June 1987 or 06/87.

The following is a brief explanation of the items to be noted on the stream survey form. The items that are underlined appear as they are noted on the survey sheet and computer. The number of spaces on the computer display are indicated.

Sign on to your Data General Computer

Go to the Information System Area

Choice: # 1. Access Information

Level: # 2. Staff

Drawer Name: FISH
Folder Name: HABITATEVALUATION
Command: FISH_MENU Your index key (shift/F2) will display the commands available to you.

ALPHA LOCK - Be sure to have your alpha lock key on so all stream names are in capitals - insuring consistency in data entry. THIS IS VERY IMPORTANT!

Main Menu: #1. Documentation Instructions will scroll on the screen. Be prepared to use your Hold key! To exit out of the documentation before it is complete Press CTRL C, Then CTRL A.

Main Menu: # 2. Add/Change/or Delete Stream Survey Data
The following screen will appear:

Please Select: _

1. Add (new stream)
2. Change/Inquire (change existing data)
3. Delete Record (delete one screen of information) Y = screen will be deleted
   N = screen will not be deleted
4. Print Record (not available at this time)

TO CANCEL OUT: Must be at the beginning of screen or the end of a screen. Press the function key F8. That will back you out one screen at a time. The second F8 takes you to -Main Menu-. From here you can select #7 (when doing a deflected access into the SO #9 is exit) to exit out of the program back to the command level in IS. CTRL/SHIFT'/F1 takes you off the system from the command level.

BREAK ESC This is used when you are entering data to a site. If you make mistakes (especially on line 1) and wish to start this site over. Press the BREAK ESC button - you will be prompted at the bottom of the screen that RECORD NOT PROCESSED PRESS CR. Just hit new line and proceed to enter the record again.

1. District # 2 spaces
(numeric code)

01 ■ Wallace
02 = Avery
03 = Fernan
04 v St. Maries
06 = Sandpoint
07 = Bonners Ferry
08 = Priest Lake
09 = Red Ives

Stream #: 3 spaces - Each stream should have its own number. The number used should be recorded on the file, form and on a stream index developed by the district.

Reach #: 2 spaces - Reaches are stream segments with the same gradient (<2%, 2 to 4%, 5 to 9%, >10%), stream order and channel type.

Site #: 3 spaces - Designates survey site number. (Data Entry: NOTE the number you give the site on the survey. forms in pencil.)

Computer Note - After hitting New line you are able to F7 down to #13 Habitat Type. Use this after first site information has been entered.

2. Stream Name: 20 spaces - Please use NF, E for example to designate North Fork or East for consisitancy also, DO NOT use Creek as part of name.

3. Date: 6 spaces - Self-explanatory

4. Forest #: 2 spaces - 04 for Idaho Panhandle

5. Elevation Start: 5 spaces - Elevations at the start and end of the reach will be determined from topography maps (numeric in feet). Altimeters will be used to locate features within the reach.

8. Elevation End: 5 spaces - The elevation of the ending point of the stream reach surveyed (numeric in feet).

7. Total Reach Distance: 5 spaces - (taken off **map** total distance in feet) Using a Planimeter, and a 7.5 minute map, code to enter is 2000. Using a Planimeter on a 1" to the mile map code is 5208.

ON MAP - Check map scale with map wheel

If using a map wheel to determine the distance, use the calculations below:

If map scale = 1 inch/1 mile, Then
$\frac{\text{Total inches}}{1}$ x 5280 ft. = Reach distance in feet

If map scale = 4 inches/1 mile, Then
$\frac{\text{Total inches}}{4}$ x 5280 ft. = Reach distance in feet

If map scale = 2.64 inches/1 mile, Then
$\frac{\text{Total inches}}{2.64}$ x 5280 ft. = Reach distance in feet

8. Valley Bottom: 1 space - Select the appropriate valley bottom type

numeric code:

CODE	VALLEY BOTTOM	DESCRIPTION
1	\/	The valley side slopes restrict the meander pattern of the stream.
2	__/	The valley side slopes influence the meander pattern of the stream.
3	____	The valley side slopes rarely influence the meander pattern of the stream.

9. Channel Type: 2 spaces - Select the appropriate channel type

numeric code:

CODE	CHANNEL TYPE	GRADIENT	VALLEY BOTTOM
01	A	>5%	\/
02	B	2-5%	__/
03	C	1%	____

10. Stream Order: 1 space - numeric - 1, 2, 3, or 4. Stream order is based on a hydrologic system in which all channels (both intermittent and annual) are considered. Map scales of 2.64 inches/mile (7 1/2 minute) will be the standard maps used in determining stream order.

11. Stream Temperature: 2 spaces - numeric in degrees centigrade

Formula: (Degrees F - 32) x 5/9 = Degrees C

12. Air Temperature: 2 spaces - numeric in degrees centigrade

13. Habitat Type: 3 spaces - numeric code

001 = Class 1 pool	005 = Run
002 = Class 2 pool	006 = Pocketwater
003 = Class 3 pool	007 = Glide
004 = Class 4 pool	008 = Riffle

Pools: Pools are basins or depressions in the channel caused by the scouring of high flows. Low surface velocities exist. Pools end where the stream bottom approaches or contacts the water surface (pool tailout) and therefore may include some glide or run.

Pools should be rated according to their area, depth, and in stream cover. These three parameters should be evaluated and assigned points based on the criteria listed on Table #1. The pool class can then be determined from the sum of these points according to the following scale:

TOTAL POINTS	POOL CLASSES
8-9	1
7	2
5-6	3
4-5	4

The total of five points for Class #3 pools must include two points for depth and two points for cover. The number of each pool class should be recorded for a length of stream within the segment being surveyed.

Foam and surface turbulence should not be used in rating pool cover, however if these cover types are significant they could be noted on the field form as "Cover Other" and identified in the "Remarks" section.

TABLE #1

PARAMETER	DESCRIPTION	POINTS
AREA	The length or width of the pool is 50% larger than the average stream width.	3
	The length or width of the pool is nearly equal to the average stream width.	2
	The length or width of the pool is 50% smaller than the average stream width.	1
DEPTH	The deepest part of the pool is greater than three feet deep.	3
	The deepest part of the pool is two to three feet deep.	2
	The deepest part of the pool is less than two feet deep.	1
COVER	> 50% (Abundant cover)	3
	25 - 49% (Partial cover)	2
	< 25% (Exposed)	1

Run: Run is a habitat type with laminar flow where the surface of the water is not disturbed by the surface of the stream bottom. The depth is generally deeper than a riffle or pocketwater and the current is less than in a pool.

Pocketwater: Pocketwater is a stream segment with boulders (greater than 1 foot in diameter) or scattered obstruction throughout what otherwise could be considered riffle. The obstructions, usually boulders, with eddy currents create numerous small pools. At least 25% of the stream segment must be comprised of pockets (not including the obstructions) to be considered pocketwater. Pocketwater is normally on steeper gradients relative to other habitat type in the reach.

Glide: Glides are run areas with velocities generally less than 1 foot/second, and a smooth surface. Water depth is generally less than 2 foot.

Riffle: Riffles are shallow water areas of higher velocities where the surface of the water is disturbed by the surface of the stream bottom. The gradient is steeper relative to other habitat types in the reach, and the surface is turbulent (white water areas). Stream depth is generally less than encountered in a pool or run.

Where 2 or more habitat types or split channels are encountered at the same site, information should be collected for each habitat type using a separate line for each habitat type (see Length, below). Braided channels should be noted in the Remarks and of the field map.

Appendix A. Continued.

	POOL	GLIDE	RUN	POCKETWATER	RIFFLE
Current:	None	Low	Yes	Yes	Yes
Depth (relative):	Most	Low/Mod	Mod	Low/Mod	Low
Obstructions: (Boulders >1 foot)				≥ 25%	≥ 25%
Gradient:	Lower	Lower	Higher	Higher	Higher

14. Length ____ (numeric): 3 spaces - length of the transect in feet. This will usually be 5 feet except on streams wider than 25 feet or where multiple habitats are encountered. For streams wider than 25 feet, transects longer than 5 feet should be used. A greater distance between transects should also be adopted. The distance and length adopted should insure that at least 10% of the reach is surveyed.

    If more than one habitat type exists across a transect, information for each habitat type should be recorded separately. The length used should be based on the percentage of the channel width occupied by the habitat type.

Percent of the Total Channel Width	Length Recorded
20	1
4o	2
6o	3
80	4

15. Width(numeric): 2 spaces - Width measurements should be taken at all sites in feet. The wetted width and not the physical channel width should be measured. The width of the watered stream channel (present) channel should be measured at a 90 degree angle to the stream flow. The measurements should be entered on the form according to the appropriate stream condition (pool, riffle, run). Actual width measurements should be taken for each habitat type, at least 5 to 10 measured in a reach and the others can be estimated.

16. Percent Gradient: 2 spaces - numeric code, e.g. 01 = 1%, 10 = 10%. Gradients should be measured at randomly selected sites along the survey. From 5 to 10 gradient measurements should be made for each reach. Clinometer measurements should be taken regularly to determine the overall gradient. Do not enter the gradient if it is over 35%.

17. Pool Creator: 2 spaces - numeric code, The factors causing the pools recorded above should be indicated. BE SURE TO ENTER A CREATOR FOR A POOL.

    01 = Large organic material (logs root wads)
    02 = Boulders, bedrock
    03 = Meanders, bank
    04 = Beaver dams
    05 = Other (note in remarks)

18-22. Cover Components (%): 2 spaces - numeric code as a percent of the stream area in pools, run, or pocketwater which has cover provided by the cover types noted. Do not consider cover in riffles. Only logs, undercut banks and vegetation within 1 1/2 feet of the stream surface would be considered as cover.

18. Large Organic Material (logs, root wads)
19. Boulders, bedrock (please note in remarks if bedrock)

20. Undercut Bank

21. Overhanging Vegetation Overhanging vegetation that acts as cover for fish, extending over water and within 18" of stream surface.
22. Other * Note in type in remarks

EXAMPLE:

00 = 0%
05 = 5%
50 = 50%
*98 = 100% not enough space for 100-ALSO computer reads 99 as end of data entry for the reach.

23. Other Cover-Type: 2 spaces - numeric code

01. = Depth (contact S.O. before establishing new cover type)
02 = Aquatic Vegetation

24. Spawning Sites Number: 2 spaces - total NUMBER (Not Area) of spawning sites for each habitat where they are found.

01 = 1 spawning site 10
= 10 spawning sites

Spawning habitat: The number of suitable spawning sites present in the habitat type. As a generalization, suitable spawning habitat for cutthroat, bull, rainbow, and brook trout will be considered a minimum area of two square feet areas consisting of gravels between 0.5 and 3 inches and with velocities between 0.5 and 3 foot per second. The bed size is a minimum of 4 feet square and usually located at pool tailouts or along banks. If this definition is not appropriate for the population using the stream, the exception should be noted on the form and percentage of the stream area in this exceptional condition should be recorded. (See additional information). If large continuous gravel beds are encountered each site should be considered 25 feet square

25. Spawning Site Creator: 2 spaces - numeric code - structure that formed the spawning site. * BE SURE TO ENTER A CREATOR FOR SPAWNING SITE.

01 = Large organic material
02 = Boulders, bedrock
03 = Meanders, bank
04 = Gradient
05 = Braiding
06 = Other (note in remarks)

Pools should not be considered as a spawning site creator. Rather the feature which is responsible for the pool should be noted.

26. Percent Fines: 2 spaces - numeric code - % fines measured in the spawning site area; a minimum of 5 samples/reach should be done. The percentage of 1/4" and smaller materials in the first 3 to 4 inches of the spawning site should be estimated.

01 = 1% 10 = 10% etc.

27. Fines-Method: 2 spaces - numeric code - the method used in measuring fines.

01 Ocular
02 = Box Sieve
O3 = Core Sample

The Habsum data base has 3 screens. The third is used to enter emergence success estimates. The columns are set up for species specific estimates and the rows indicate the method used to derive the estimate.

SCREEN 3

EMERGENCE:	CUTTHROAT	RAINBOW	BULLTROUT	BROOKTROUT	KOKANEE	OTHER
METHOD 1:	1.	2.	3.	4.	5.	6.
METHOD 2:	7.	8.	9.	10.	11.	12.

Method 1 is based upon Bjornn and Irving's, (1984) relationships using 1/4" fines and the box sieves.

Method 2 is based upon Bjornn and Irving's, (1980) relationships using 0.85 mm and 9.5 mm box sieves.

Method 6 is based upon Bjornn and Irving's, (1984) relationships using 1/4" fines from core sample.

Method 7 is based upon Bjornn and Irving's, (1984) relationships using O.85 mm and 9.5 mm sieve and core samples.

Method 10 row is reserved for the emergence estimate based on the Forest Plan survival curve (Entry Number 55). Entries 56 – 60 can be used to evaluate survival levels resulting from project alternatives.

Methods 3, 4, 5, 8, and 9 have not been identified but will be in future.

28 & 29 Remarks - space available (Enter surveyor's remarks e.g. sediment sources, habitat improvement projects, data collected from core samples, ocular, box sieve. Please also note fish species, quantity and sizes. The features such as debris jams, slides, and channel braiding should be noted in the remarks section and on the survey map.

Computer Note CTRL E - will allow you to insert space if needed between words, on allotted line. CTRL F moves cursor to next word. CTRL B moves cursor back.

30. CODE: 0 (LEAVE BLANK!) USED TO MARK END OF DATA BASE BY COMPUTER!

Any Changes? Opportunity to change incorrect information except for line #1. Enter field number, NEW LINE, then the change to be made.

At the end of each stream reach enter another site number. From #13 – #27 enter **all spaces with** 9's to signal computer end of reach.

#28 & 29 enter 99.   #30 CODE: 0 (LEAVE BLANK!).

FORM 2

Sample # : Bottom materials should be sampled when width. measurements are taken on riffles and runs. Record a sample number on form # 1 beside the appropriate width sample. This number should then be recorded in the first column of Form 2.

Habitat Type: Same numeric codes as on Form 1.

Width: Stream width (Record to the nearest Foot)

Depth: The depth of the stream should be taken at points in the middle and one quarter of the stream width from each bank. The sum of these readings should be divided by four (4) to account for the "0" depth reading at the banks. Entries should be made in the appropriate box (pool, run, and riffle).

Depth 1/4 - Depth halfway between bank and the center of the stream (Record to the nearest inch)

Depth 1/2 - Depth in the center of the stream

Depth 3/4 - Same as 1/4 but on other side of the creek.

Velocity: Velocity should be determined by using a pygmy meter or other established devices, or by noting the time required for a reference point in a stream (weighted float, stick. etc.) to be carried a set distance down the channel.

Measurements should be taken in the middle of the stream and one quarter of the stream width from each bank. The average of these measurements should be recorded.

Bottom Materials: The percentage of each bottom material size group located in pools, riffles, and runs (if they are all present) should be estimated.

% Clay / Silt - % of stream bottom which is composed of clay or silt

% Sand - Same as above for sand

% .1 to .25 - % Fine gravel 1/10 of an inch in size to 1/4 of an inch

% .25 to 3 - % Coarse gravel 1/4 of an inch to 3 inches in size %

3" to 6" - & Small Rubble 3" to 6" in size

% 6" to 12" - % Large Rubble 6" to 12"

% Boulder

% Bedrock - Total of % Clay/Silt thru % Bedrock should add up to 100%

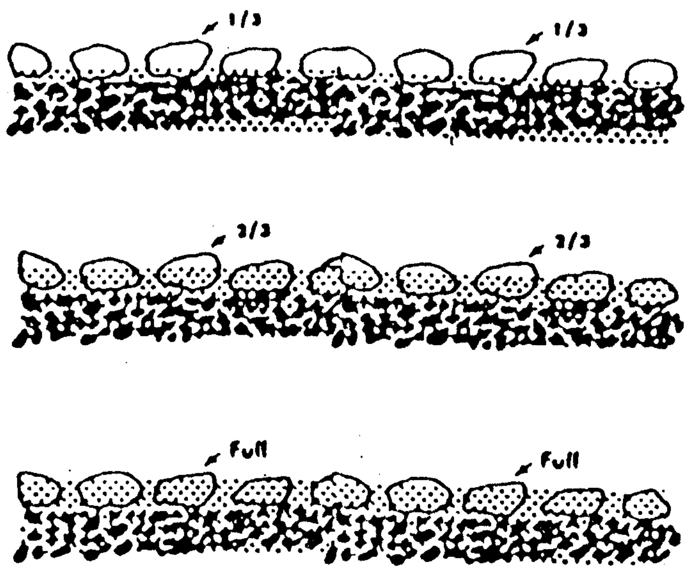
% Aqua Veg - % of stream bottom with aquatiac vegetation

Aquatic Vegetation: The relative abundance of submerged or emergent, aquatic vegetation should be indicated according to the following scale:

Abundant (A) > Common (C) > Present (P)

Appendix A. Continued.

Embeddeness: **The percent embeddedness of the gravels in the spawning sites should be assessed according to the following descriptions:**



Volume: Volume measurements should be made based upon the above data using the following formula:

Q = (W) (D) (V) 0.8 or 0.9 =

Where: Q = Discharge in cubic feet per second

W = Width of the stream in feet D =

Depth of the stream in feet

V = Velocity of the stream flow in feet per second

0.8 = The correction factor for streams with an irregular, rocky bottom

0.9 = The correction factor for streams with a smooth, sandy bottom

RIPARIAN STANDS:

Stand Number: Enter numeric - A variety of vegetative stands may be encountered on the streambanks in a particular reach. A number, letter or elevation should be used to identify each stand. The number or letter should also be noted on the topography map used during the survey.

Starting Elevation: Enter numeric

Ending Elevation: Enter numeric

Succesional Stage - 01 Seedling Newly planted clearcuts with trees less than four and one-half feet tall (1 to 10 year old managed stand)

02 Sapling Trees four and one-half tall or greater but with an average DBH less than 5 inches (10 to 40 year-old manages stand)

03 Pole Trees with an average DBH of 5 to 9 inches (40 to 70 year old stand)

04 Imature Trees with an average DBH of 9 inches to 14
100 year-old manages stand)

05 Mature Trees with an average DBH of 14 to 20 inches (100 to 160 year-old managed stand)

06 Old-Growth Trees with an average DBH exceeding 20 inches or over 160 years in age

07 Meadow

08 Low-Shrub Shrubfields with an average height of less than 6 feet

09 High-Shrub Shrubfields with an average height of greater than 6 feet

10 Meadow/Timber Mosaic

11 Low-Shrub/Timber Mosaic

12 High-Shrub/Timber Mosaic

Diversity: 1 - Low One age class

2 - Moderate Two age classes (Overstory with a managable

3 - High Numerous age classes, good interspersion

Logged: 1 - Unlogged

2 - Clearcut

3 - Partial Cut

Major Tree Species: Record letter code AF, WH, C, WP, L, S, LP, MH, OF, DO, etc.

AVG DBH: Estimate average DBH to the nearest inch

AVG HGT: Estimate average stand height, to the nearest foot

Mortality:

1 - Low	Little evidence of mortality
2 - Moderate	Some evidence of diseased or high risk trees
3 - High	Numerous dead trees. Lots of evidence of disease or high risk trees.

Major Shrub Species: Record major species which represent the predominant character of the area. Use four or five letter species codes like those found in the Field Guide to Forest Plants of North Idaho. For example:

Shrubs	ACGL	Mountain Maple	SASC	Scouler Willow
	ALNUS	Alder	OPHO	Devils Club
	AMAL	Serviceberry	MEFE	Menziesia
	COST	Red Osier Dogwood		
Forbs	HELA	Cow Parsnip	ANAR2	Angelica
	VEGA	False Hellebore	LICA2	Licorice Root
Gaminoids	GRASS	Don't worry about species, but put down if you know it		
Sedges	SEDGE	Again don't worry about species		

Riparian Width: Average width of the riparian zone to the nearest foot

_ Side Slope: Appoximate the gradient of the valley sideslopes

Limiting Factors: Factors which appear to be responsible for limiting trout production, habitat suitability and/or habitat utilization should be noted.

Recommended Projects: Possible stream habitat improvement projects should be itemized. The size of the project, manpower needs, and equipment requirements should be included. (Sediment source stabilization, pool structures, tree felling, block removal, etc.)

Landmarks: Geographic features which will aid in locating where the survey was begun and where it ended should be indicated.

Investigator: The individuals who performed the survey should be listed. In case the need arises for additional questions.

Appendix B. Salmonid Embryo Survival Estimators

Tappel Method (Tappel and Bjornn 1981)

The Tappel method is predicated on a log-linear distribution of stream-sorted sediments and uses the percentage of sampled substrate less than 0.85mm and 9.2mm in diameter in a regression equation which predicts embryo survival from the sediment mixtures described by those two particle sizes, based on a linear distribution. With this method, I used equations developed for cutthroat trout embryo survival by Irving and Bjornn (1984):

$$\text{Percent survival} = 102.83 - 0.838\ (\%\ 9.5) - 9.29\ (\%\ 0.85) + 0.386\ (\%\ 0.85)^2$$

$r^2 = 0.94$

% 0.85 = percent sediment less than 0.85 mm
% 9.5 = percent sediment less than 9.5 mm

Fredle Index (Lotspeich and Everest 1981)

The Fredle index is based on the relationship between salmonid embryo survival and the Fredle number (fi). The Fredle number is a measure of the porosity and permeability of stream substrates, characteristics which are primary determinents of salmonid embryo survival-to-emergence. The Fredle statistic is derived by dividing the geometric mean (d_g) by the sorting coefficient (So) of the stream substrate sample. Because d_g is directly proportional and S_o is inversely proportional to sediment porosity and permeability, f_i is a proportional measure of substrate porosity and permeability. Consequently as f_i increases, so does embryo survival.

To estimate cutthroat trout embryo survival using the Fredle index, I developed a predictive least squares linear regression equation using known Fredle numbers and embryo survival percentages for identical gravel mixtures reported by Tappel (1981) and Irving and Bjornn (1984).

$$\text{Percent survival} = -2.94 + 5.42\ (f_i)$$

$r^2 = 0.74$

Appendix C. Summary statistics from analysis of substrate core samples collected from Taft-Bell monitoring streams, northern Idaho, 1985. Reported values are means.

Stream	n	s_o	d_g	f_i	Percentage of fine substrate <0.8 mm	<9.5 mm	<6.4 mm
Alder	10	2.95	14.19	5.00	3.5	28.8	19.9
Black Canyon	15	2.85	17.16	6.26	0.6	24.5	12.9
Bootjack	15	5.52	2.88	5.52	3.1	34.8	24.8
Burnt Cabin	15	4.25	2.98	4.25	2.2	38.6	26.5
Cascade	14	4.47	3.10	4.47	1.6	34.4	20.7
Cedar	15	4.44	3.13	4.44	3.1	30.0	23.2
Copper	15	4.26	3.29	4.26	3.4	29.0	19.3
E. Fk. Hayden	15	3.36	3.55	3.36	3.6	37.6	28.2
Hemlock	9	3.92	3.03	3.92	1.4	41.3	29.8
Hudlow	15	3.29	12.55	3.85	2.8	36.9	26.8
Laverne	15	3.45	8.32	2.42	4.4	50.1	40.3
Leiberg	15	3.44	12.52	3.64	2.7	42.6	31.2
Line	14	2.94	14.66	5.14	2.3	29.9	19.9
Nicholas	13	3.35	13.03	3.98	2.0	34.8	24.6
N. Fk. Hayden	15	3.19	10.22	3.31	3.8	39.5	28.1
Omaha	13	2.61	13.48	5.31	1.1	34.5	23.7
Picnic	15	2.75	19.71	7.42	0.8	21.7	14.7
Scott	12	3.68	9.97	2.76	4.9	44.5	34.2
Skookum	15	2.68	15.47	5.84	2.2	26.1	15.8
Smith	5	2.87	15.34	5.43	1.5	30.7	19.5
Tie	14	3.14	11.61	3.68	2.5	44.5	30.5

LEGEND:

n = sample size
s_o = sorting coefficient
d_g = geometric mean
f_i = dg/so

COMPREP

Appendix D. Summary statistics from analysis of substrate core samples collected from Taft-Bell monitoring streams, northern Idaho, 1986. Reported values are means.

Stream	n	s_o	d_g	f_i	Percentage of fine substrate <0.8 mm	<9.5 mm	<6.4 mm
Alder	7	3.4	14.0	4.1	2.5	33.0	25.5
Black Canyon	12	2.7	17.7	6.8	1.0	26.0	16.5
Bootjack	15	2.5	17.8	7.3	0	26.0	16.0
Burnt Cabin	19	3.3	13.8	4.2	1.0	36.0	27.0
Cascade	29	3.0	15.2	5.1	1.7	33.4	24.0
Cedar	8	2.8	18.7	7.0	0	24.3	22.7
Copper	14	3.3	16.4	5.0	2.7	26.7	19.7
E. Fk. Hayden	15	3.0	13.1	4.4	1.0	36.0	25.3
Hemlock	11	2.7	13.9	5.2	0	37.0	24.0
Hudlow	14	2.9	15.6	5.5	2.0	30.0	20.3
Laverne	17	3.5	13.9	4.0	2.0	36.7	28.7
Leiberg	33	3.3	12.5	3.8	1.3	38.5	28.0
Line	14	3.2	13.3	4.2	2.0	33.0	23.0
Nicholas	10	3.1	7.2	8.0	1.6	35.6	24.8
N. Fk. Hayden	17	3.2	13.9	4.4	1.5	32.3	23.8
Omaha	10	3.1	12.5	4.2	2.0	40.0	28.0
Picnic	15	2.8	17.3	6.2	1.0	25.0	17.7
Scott	12	3.7	13.4	3.7	2.7	34.7	26.0
Skookum	15	3.0	17.9	6.0	1.0	22.3	15.7
Smith	10	2.8	17.5	6.3	1.0	24.5	15.5
Tie	13	3.3	12.3	3.7	1.7	39.0	28.0

LEGEND:

n = sample size
s_o = sorting coefficient
d_g = geometric mean
$f_i = d_g/s_o$

Appendix E. Mean substrate embeddedness, free particle incidence and overyearling trout densities in Taft-Bell monitoring streams, northern Idaho, 1985.

Stream	Percent embeddedness	Percent free particles	Overyearling trout/100 m^2
Hudlow	16	66	8.1
Cedar	19	59	1.2
Line	19	65	4.9
Black Canyon	19	59	10.3
Copper	20	61	12.5
Tie	20	56	6.2
Picnic	20	61	6.3
Smith	21	51	0.0
Burnt Cabin	23	55	0.0
Nicholas	24	36	5.1
Bootjack	24	51	2.1
Scott	24	54	10.2
Omaha	25	46	7.9
Laverne	26	49	4.4
Hemlock	26	52	2.5
Leiberg	29	44	8.1
Skookum	29	35	0.9
E. Fk. Hayden	28	45	26.6
Alder	31	39	2.9
N. Fk. Hayden	34	28	46.7
Cascade	36	27	5.2

Appendix F. Mean substrate embeddedness, free particle incidence and overyearling trout densities in Taft-Bell monitoring streams, northern Idaho, 1986.

Stream	Percent embeddedness	Percent free particles	Overyearling trout/100 m^2
Hudlow	17	67	
Cedar	19	59	0.7
Line	20	62	29.9
Black Canyon	20	58	12.4
Copper	14	73	14.0
Tie	19	60	13.1
Picnic	16	64	9.4
Burnt Cabin	21	62	--
Nicholas	18	64	5.2
Bootjack	20	56	1.3
Scott	17	62	7.9
Omaha	24	51	18.3
Laverne	19	54	4.4
Hemlock	21	59	6.1
Leiberg	21	55	6.8
Skookum	14	68	--
E. Fk. Hayden	16	66	39.4
Alder	23	54	5.0
N. Fk. Hayden	18	62	60.8
Cascade	21	61	3.8

Appendix G. Mean percent cutthroat trout embryo survival estimates (Tappel method) and observed overyearling cutthroat trout densities in Taft-Bell monitoring streams, northern Idaho, 1985.

Stream	Percent embryo survival	Overyearling/100 m^2
Black Canyon	77	10.3
Picnic	77	7.5
Omaha	64	7.9
Cascade	60	2.6
Line	58	4.9
Nicholas	57	5.1
Hemlock	56	2.5
Alder	51	2.3
Leiberg	45	8.0
Hudlow	49	8.1
Skookum	62	0.4
Copper	51	8.9
E. Fk. Hayden	43	24.5
Tie	45	5.8
N. Fk. Hayden	41	46.7
Cedar	53	0.5
Bootjack	49	2.1
Scott	29	10.2
Laverne	27	4.4

Appendix H. Mean percent cutthroat trout embryo survival estimates (Tappel method) and observed overyearling cutthroat trout densities in Taft-Bell monitoring streams, northern Idaho, 1986.

Stream	Percent embryo survival	Overyearling/100 m^2
Black Canyon	74	12.4
Picnic	76	9.4
Omaha	58	18.3
Cascade	62	3.8
Line	55	29.9
Nicholas	54	5.2
Hemlock	68	6.1
Alder	54	5.0
Leiberg	54	6.8
Copper	56	14.0
E. Fk. Hayden	61	35.2
Tie	55	13.4
N. Fk. Hayden	59	56.6
Cedar	80	0.0
Bootjack	72	1.3
Scott	48	7.9
Laverne	55	4.4

Appendix I. Mean percent cutthroat trout embryo survival estimates. (Fredle method) and observed overyearling cutthroat trout densities in Taft-Bell monitoring streams, northern Idaho, 1985.

Stream	Percent embryo survival	Overyearling/100 m^2
Picnic	37	7.5
Black Canyon	31	10.3
Skookum	29	0.4
Bootjack	27	2.1
Omaha	26	7.9
Smith	26	0.0
Line	25	4.9
Alder	24	2.3
Cascade	21	2.6
Cedar	21	0.5
Burnt Cabin	20	0.0
Copper	20	8.9
Nicholas	19	5.1
Hemlock	18	2.5
Hudlow	18	8.1
Leiberg	17	8.0
Tie	17	5.8
E. Fk. Hayden	15	24.5
N. Fk. Hayden	15	46.7
Scott	12	10.2
Laverne	10	4.4

Appendix J. Mean percent cutthroat trout embryo survival estimates (Fredle method) and observed overyearling cutthroat trout densities in Taft-Bell monitoring streams, northern Idaho, 1986.

Stream	Percent embryo survival	Overyearling/100 m^2
Picnic	31	9.4
Black Canyon	42	12.4
Bootjack	37	1.3
Omaha	20	18.3
Line	20	29.9
Alder	20	5.0
Cascade	25	3.8
Cedar	35	1.0
Copper	24	14.0
Nicholas	20	5.2
Hemlock	25	6.1
Leiberg	18	6.8
Tie	17	13.1
E. Fk. Hayden	21	35.2
N. Fk. Hayden	21	56.6
Scott	17	7.9
Laverne	19	4.4

Appendix K. Mean values for percent of substrate core samples less than 6.4 mm in diameter and overyearling trout densities in Taft-Bell monitoring streams, northern Idaho, 1985.

Stream	Percent sediment <6.4 mm	Overyearling/100 m^2
Black Canyon	12.9	10.3
Picnic	14.7	6.3
Skookum	15.8	0.9
Copper	19.3	12.5
Alder	19.9	2.9
Line	19.9	4.9
Omaha	23.7	7.9
Cascade	20.7	5.2
Cedar	23.2	1.2
Nicholas	24.6	5.1
Bootjack	24.8	2.1
Hudlow	26.8	8.1
N. Fk. Hayden	28.1	46.7
E. Fk. Hayden	28.2	26.6
Hemlock	29.8	2.5
Tie	30.5	6.2
Leiberg	31.2	8.1
Scott	34.2	10.2
Laverne	40.3	4.4

Appendix L. Mean values for percent of substrate core samples less than 6.4 mm in diameter and overyearling cutthroat trout densities in Taft-Bell monitoring streams, northern Idaho, 1986.

Stream	Percent sediment <6.4 mm	Overyearling/100 m^2
Black Canyon	17.	12.4
Picnic	18.	9.4
Skookum	16.	--
Copper	19.	14.0
Alder	26.	5.0
Line	23.	29.9
Omaha	28.	18.3
Cascade	24.	3.8
Cedar	16.	1.0
Nicholas	28.	5.2
Bootjack	16.	1.3
Hudlow	20.	
N. Fk. Havden	23.	68.5
E. Fk. Hayden	25.	39.4
Hemlock	24.	6.1
Tie	28.	13.4
Leiberg	28.	6.8
Scott	26.	7.9
Laverne	29.	

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